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DIVISION OF WATERSHED MANAGEMENT RESEARCH

Semiannual Report

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

October 1955 - March 1956

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SEMIANNUAL REPORT
Division of Watershed Management Research
October 1955 - March 1956

Washington Office

The chief value of this Semiannual Report is providing a means of exchanging information between watershed management research people. As part of this process it should not be overlooked that comments and discussions regarding things appearing in this report are entirely in order and highly desired. This is a good place to "try it on the dog." If you have a hair-brained idea that seems pretty good, put it in the report and let the rest of the gang shoot at it. Also, if you run across something in here that appears all wet, put your ideas down right then and include in the next report. If you wait until the next report is about due, you won't bother with discussions. Thus speaks one of the more expert procrastinators.

Incidentally, judging from the Northeastern Station's present report (see page 3 NE Sta.), they have a number of holes that might be available for transfer or exchange. Maybe a western station might use them for postholes on an experimental range. Also, in the NE Station report, page 4, note that they would appreciate some suggestions from some of you mathematical geniuses as to possible procedures to use in developing calibration relationships for their Fernow watersheds.

The PNW Station now has debris basins on three watersheds on the H. J. Andrews. Bedload caught in these basins will be determined by annual profile measurements in each basin. Suspended sediment sampling will be made of the overflow at the spillways. Two thoughts occur: (1) Shouldn't samples be taken within the basins to determine the amount of compaction due to settling; (2) Maybe some thought should be given to trap efficiency as was done by the CAL Station with the Teakettle sediment analysis. (See CAL report, page 4.)

Watershed 17 at Coweeta was treated by cutting all woody plants that had sprouted since the last mowing operation, then all the cut stems and stumps were sprayed with a solution of 2-4-5T in fuel oil. Two months following the spraying operation planting of the area with white pine was started. (See SE Sta. report, page H-6) The NE Station has had some experience in planting shortly following spraying with 2-4-5T and ammate. In one case they planted within a week of spraying and had little or no survival. This was reported in a station research note. They next tried planting about two months after spraying and, according to their semi-annual report Oct. 1955, page 8, had very low survival. It will be interesting to see if the Coweeta planting is more successful. Maybe the amount of rain between the time of spraying and when planting is started might be an important factor in governing whether holdover effects of the chemicals will prove detrimental to the planting.

(Over)

Discussion

What do we mean by "Safe Limits of Watershed Use"? From time to time statements appear indicating that certain intensities of land use increase soil loss or surface runoff rates beyond safe limits. Usually the loss rates are associated with the percentage and distribution of shrubby or herbaceous ground cover.

Since the term "safe" connotes a subjective evaluation, involving considerations that go beyond the purely physical aspects of our watershed research, how justified are we in using it? Even on a purely physical basis, our measurements are commonly restricted to the more immediate on-site effects, leaving unanswered, or partially answered, the extent to which watershed functions—yields, peaks, sediment production, quality, etc.—may be affected. Even where such analyses are available, the problem of determining "safe" limits objectively remains far from solved.

Perhaps an approach from the opposite viewpoint may help us develop some quantitative physical criteria on which administrators, economists, and policy makers may build in determining what rates of soil and water losses might be justified under given circumstances and in given periods. Such an approach involves collecting and analyzing information—from past records (including historical events), P-RO relations, and trends in peak discharges, sediment production, etc.—as a means of indicating what magnitudes and frequencies of discharge, etc., clearly represent damaging phenomena. If it can be established that all or part of the adverse effects of such phenomena are associated with changing watershed characteristics growing out of human activity, we come that much closer to correlating our soil and water loss data from limited areas with overall watershed performance.

Much progress has been achieved in the above respects, but it has been rather spotty. The knowledge that our research findings will sooner or later be put to practical use makes it desirable that we continually view our plans and studies--especially in applied research in terms of seeking ways and means for extracting the most useful information out of them. At the same time we may need to recognize the limitations of our studies and their results in providing directly applicable guides to watershed management, including determinations of "safe" use.

Intermountain: Page 7, Wasatch R. C., Table 2 - Such high sediment rates from the Davis County watersheds, most of whose areas are in national forest, further emphasize the danger of floods and debris to residential developments—existing and projected--in the mouths of the above canyons. Most of these watersheds have received some treatment, yet the sediment rates still remain excessive. It is hoped that steps have been taken to notify local agencies of the potential threats to life and property and to accelerate the measures for reducing rates (via further treatments and land-use management).

The above situation also increases the desirability of an early revision of M. P. No. 639 to reflect present watershed conditions and downstream developments, and to appraise the need for further treatment and management.

Intermountain: Pages 8-9, re Spurious Correlation - Will these comments be submitted for publication in the AGU Transactions? (B. Frank)

ARS Work Planning Conference, Coshocton, Ohio, March 1-2, 1956

Dr. Wadleigh stressed need for fundamental or basic research; he cited the Quarterly Report as one method of responding to SCS needs and stressed effective liaison between the two services.

Mr. Ackermann stressed need for examining program from two viewpoints: (1) What are SCS research needs on which we can work, and (2) How can we use the watersheds to best advantage in testing new developments from outside sources? He felt the present problem was not one of conservation vs. practices 20 years ago, but rather how best to anticipate new developments for which we will need answers on a watershed basis.

Field Tour - Woodleigh: We need to relate quantitatively the relation of an infiltration index as determined on a watershed basis with the relative readings from concentric rings or other infiltrometer set-ups.

Ackermann: Big job is to get out information on water yield and peak rates for all experimental watersheds. ARS now preparing monthly summary of precipitation and runoff values for later insertion on U. S. map as basis for interpolations. He cited the WB method of combining short-time Q records with long-time P records as one approach to filling in gaps.

Suggested Reading

Fifth Annual Report National Science Foundation, F. Y. 1955, especially
Part I Current Aspects of American Science
II Program Activities of the NSF

Annual Report of the Smithsonian Institution, 1954
Pages 179-188 - The nature of the upper atmosphere
" 189-200 - Solar influence on the earth
" 317-336 - The romance of domesticated plants

"Where is Science Taking Us?" Saturday Review, March 24, 1956.
(Page 56 - The case for pure research)

SIPRE Publications on hand (available on loan)

1. "Contribution to the theoretical foundations of avalanche defense construction," 1948. Translation 18 (German)
   Ch. I - Technical analysis of the material snow (4 sections)
   " II - Statics and dynamics of the snow cover (4 sections)
   "III - Avalanche defense construction (4 sections)
   (Summary and Bibliography)

2. "Studies on snow cover." Transl. 38 (Japanese), 9 pp. 1941. (SIPRE appraises this report as more valuable for prediction method than for factual data, and indicates that important advances in forecasting volume and duration of melt water runoff are available in the literature.)

3. "Snow characteristics project." Final progress report, U. of Cal. Inst. of Eng. Research. 122 pp. Aug. 31, 1955. ("The initial objective was directed toward the collection of basic data pertinent to the development of camouflage and detection techniques in snow covered areas. Although this objective was not attained a promising group of instruments has been developed which may be useful in the eventual solution of problems dealing with low temperature emissivity and reflectivity of materials.")

4. "Avalanche conditions and avalanche research in the United States, with recommendations for future work." SIPRE Report 29. July 1955. (29 pp.)

5. "Investigation of description, classification, and strength properties of frozen soils." SIPRE Report 8. 2 volumes. June 1952. (Vol. 1 - report of investigations; Vol. 2 - investigational data)

6. "Excavation of frozen ground." Transl. 53. Nov. 1955. 4 pp. (equipment and operations).

7. "Properties of snow and its density." Transl. 32 (Japanese). 21 pp. Nov. 1954. (Data from 2-year experiment - micro and macro analyses).

8. "Electrical resistance of snow." Transl. 31 (Japanese). 4 pp. Nov. 1954. (Differences between values for soil and those for snow are utilized in snow depth measurement.)

9. "Measurement of the thermal conductivity of snow cover." Transl. 30 (Japanese). 7 pp. Nov. 1954. (Part of a series on "Physical studies of snow covers.")

10. "Methods of temperature observations on a snow surface." SIPRE Transl. 29 (Russian). 7 pp. July 1953. (Evaluation by SIPRE; a poor paper: no new scientific information; value merely in indicating methods used by Russian hydromet. service.)

11. "Mechanics of frozen ground." Transl. 25 (Russian). 20 pp. Feb. 1954. (Pages 14-20: Comments and criticisms by Translator)

12. "Calculations of snow-cover density using meteorological data." Transl. 24 (Russian). 4 pp. Jan. 1954.

13. "Physical processes in a snow cover." Transl. 15. 17 pp. Jan. 1952.

14. "Snow and its metamorphism." Transl. 14 (German). 313 pp. Jan. 1954. (Investigations by The Swiss Federal Institute for Snow and Avalanche Research.)

15. "Freezing and thawing of soil." Transl. 11 (Russian). 8 pp. Jan. 1950. (Covers range of meadow and forest soils under pine with various understory vegetation.)

16. "Snow cover, its formation and properties." Transl. 6 (Russian). 113 pp.+. 1945.

17. "Instructions for making and recording snow observations." Instruction Manual 1. 20 pp. May 1954. (looseleaf; illus., including photos of snow surfaces)

18. "Review of the properties of snow and ice." SIPRE Report No. 4. 156 pp. July 1951. (Purpose to provide background for organizing research program and to summarize the information on subject.)

19. "Preliminary investigations of some physical properties of snow." SIPRE Report No. 7. 48 pp. + diagrams. June 1951. (Theory, preliminary experimental results, instrumentation)

20. "Review of certain properties and problems of frozen ground including permafrost." SIPRE Report No. 9. 124 pp. March 1953.

21. "Some aspects of snow, ice and frozen ground." SIPRE Report 10. 32 pp. August 1953. (Problems and review of knowledge of snow, ice, and frozen ground, and research needs)

SEMIANNUAL REPORT

Division of Watershed Management Research
California Forest and Range Experiment Station

October 1955 - March 1956

PERSONNEL

Edward A. "Ted" Colman, our Division Chief, died March 20 after a short illness. The first week in March, Ted was in the field in northern California, and appeared to be in excellent health. The second week he went to southern California where he became ill on March 16. He flew home to Berkeley that evening and entered the hospital the following day. He suffered from some deep-seated, virulent infection that would not yield to treatment. Diagnosis of the trouble is still incomplete. Medical tests are continuing, with a virus being the suspected cause of death.

In Ted Colman the Watershed Management Research group in California had a true personal friend and an outstanding leader. Ted's professional contributions including numerous technical papers, his book "Vegetation and Watershed Management", his soil moisture meter, and his participation in numerous technical groups and committees, are well known. Not so well known, perhaps, were Ted's qualities of leadership and human understanding that endeared him to those privileged to work with him. Ted was always ready to give his time to help his staff members do better work. His counsel was valued by all who were fortunate enough to receive it. His ability to get to the heart of a problem, sift out its essentials, and plan its solution simply and with great logic will remain a challenge and inspiration to his co-workers.

Until a new Chief can be appointed, Henry W. Anderson has been designated to act as head of the Division.

Kenneth J. Walsh reported to the Berkeley Center to head up meteorology and snow physics studies in the Snow Research Program. Walsh was formerly with the Corps of Engineers in its Snow Investigations in California, and in the Snow, Ice, and Permafrost Research Establishment in Michigan.

Said Katana, graduate forestry student who worked in the Snow Research Program in 1955, returned early in 1956 to Iraq.

Paul J. Zinke reported to the San Dimas Research Center on November 10, having transferred from the Station's Division of Forest Economics, Soil-Vegetation Survey group, to take over the soil movement studies formerly handled by H. W. Anderson. In January, Paul was awarded the Ph.D. degree in Soil Science by the University of California at Berkeley. Paul is not a newcomer to San Dimas, having worked there in 1947-48.

Geoffrey B. Coleman, Junior Forester, reported to the San Dimas Research Center on January 16. He was transferred from the Los Padres National Forest and will assist Henry Hellmers with the vegetation studies in the Los Angeles River Watershed.

PUBLICATIONS

Manuscripts Published

"Conquering Kennett's Gullies" by C. J. Kraebel. American Forests, December 1955. (Described in Semiannual Report, October 1954-March 1955, page 5.)

"Root Systems of Some Chaparral Plants in Southern California" by Henry Hellmers, J. S. Horton, G. Juhren, and J. O'Keefe. Ecology 36(4), October 1955. (Described in Semiannual Report, October 1953-March 1954, page 3.)

"Progress Report, Stabilization of Critical Sediment Sources, Los Angeles River Watershed" by H. Hellmers and H. W. Anderson, 12 pp. mimeo., November 1955.

Manuscripts Accepted for Publication

"Forest Cover Effects on Snow Accumulation and Melt, Central Sierra Snow Laboratory" by H. W. Anderson, has been accepted for publication in the Transactions of the American Geophysical Union, and is scheduled for the June 1956 issue. Some results of this study were described in the Semiannual Report for April-September 1953.

New Manuscripts

"Relating Sediment Yield to Watershed Variables" by H. W. Anderson, is being prepared for presentation at the Symposium on Watershed Erosion and Sediment Yields at the annual meeting of the American Geophysical Union in Washington, D. C., April 30-May 2.

"The San Dimas Soil-Core Sampler--Its Modification and Use" by L. A. Andrews and W. M. Broadfoot. A sampler to obtain virtually undisturbed cores of soil, developed on the San Dimas Experimental Forest, then modified and used extensively by the Forest Service Infiltration Project at Vicksburg, will be described in this paper proposed for submission to Soil Science for a joint publication by the California Station and the Infiltration Project.

CURRENT RESEARCH

SNOW STUDIES

Formal watershed management research in California's snow zone got under way late in 1955. Objective of the studies is to develop watershed management methods which will improve the yield of water from the high-elevation snow zone.

The studies contemplated fall under four headings:

1. Evaluate the water resource in the snow zone of the State to determine the amount and timing of water yield from various parts of watersheds.

2. Develop methods of classifying the forest types and sites of the State into groups having different effects on water yield.

3. Develop and test methods of increasing water yield, changing the timing of water yield, and maintaining water quality for the various water yielding units in the snow zone.

4. Pilot test the most promising methods on whole watersheds to measure the effects on streamflow and sedimentation.

To conduct this research, a small staff is now at work and one of two available snow laboratories has been activated. If present prospects for cooperative assistance in this research materialize, the staff will be expanded and the other snow laboratory will be activated. Already in operation is the Teakettle Snow Laboratory, in the Kings River Basin. The other is the Central Sierra Snow Laboratory, in the headwaters of the Yuba River.

The Teakettle Snow Laboratory was established in 1938. A laboratory building was constructed at that time and four small forested watersheds were equipped with reservoirs to catch sediment and gages to measure streamflow. The laboratory was operated 2 years and then closed because of lack of funds. Since establishment, however, the reservoirs have caught sediment delivered from their watersheds, and the accumulated sediment has been measured from time to time. These measurements provide an opportunity to evaluate sedimentation in watersheds on which the timber will later be cut to pilot-test the promising methods of snowpack management. We need this evaluation because one objective of snow research is to learn how to improve water yield without excessively increasing sedimentation.

At the Teakettle Snow Laboratory there are four experimental watersheds located in old growth California red fir, at elevations ranging from 6,400 to 8,100 feet. Characteristics of these watersheds and experimental installations are summarized in Table 1.

Table 1.--Watershed, reservoir, and gaging station characteristics, Teakettle Snow Laboratory, California.

Characteristic	Watershed 1	Watershed 2	Watershed 2a	Watershed 3
Drainage area (acres)	490	542	175	548
Reservoir capacity (acre-feet)	0.390	0.134	0.079	0.131
Reservoir surface area (acres)	0.087	0.040	0.026	0.035
Weir capacity (cfs)	200	200	135	200

Periodic sedimentation measurements for the Teakettle watersheds are given in Table 2, together with the average reservoir capacity and the average relative peak discharge (of the nearby Kings River) for each period. The sedimentation data were analyzed for two purposes: (1) to determine the mean annual sedimentation for each watershed and the effect of a small burn in No. 1, and (2) to test the degree of calibration achieved for detecting effects of future treatments on sedimentation.

Table 2.--Periodic sedimentation (sed.), capacity-watershed area ratios (c/w), and relative peak discharges, Teakettle Snow Laboratory, California.1/

Period 2/ (fall to fall)	Watershed 1		Watershed 2		Watershed 2a		Watershed 3		Relative peak discharges
	Sed.	c/w	Sed.	c/w	Sed.	c/w	Sed.	c/w	
	AF	AF/sm	AF	AF/sm	AF	AF/sm	AF	AF/sm	cfs/cfs
1938-40							.0026	.151	.709
1940-41							.0204	.138	1.124
1938-41					.0146	.270			.848
1941-48					.0084	.210	.0112	.089	.951
1938-48	.0271	.370	.0066	.126					.920
1948-51	.1100	.120	.0250	.059	.0320	.150	.0160	.029	1.224
1951-55	.0077	.002	.0080	.014	.0110	.090			.968
Mean per sq. mi. per yr.	.0371		.0102		.0140		.0115		

1/ The capacity-watershed area ratio is the average capacity of the reservoir below spillway level in the period divided by the watershed drainage area. Relative peak discharge is the mean of the annual peak discharges of the period divided by the mean of the annual peak discharges for the 34-year period, 1922-55; discharges are of North Fork Kings near Cliff Camp, California.

2/ Small burn occurred in this watershed in 1943; the others are unburned.

For both purposes it was necessary to correct the periodic measurements of sedimentation for variations between periods in the relative discharges and in the trap efficiency of the reservoirs. To obtain a basis for the corrections, covariance analysis was used, with the periodic measurements of sediment being the dependent variable and the relative discharge in each period and the average capacity of the reservoir per unit of watershed area as the covariants. Watersheds 2, 2a, and 3 were used in this analysis; watershed No. 1 was not included because of the burn. For the three watersheds analyzed, the pooled within-regression was not significantly different from the individual regressions so the within-regression was used. It is:

Sediment Deposition (AF/sq.mi./yr.)	=	0.052	Relative Discharge (cfs/cfs)	+ 0.045	Capacity Watershed Ratio (AF/sq.mi.)	-0.043

The standard error of estimate was ± 0.0046 AF/sq.mi./yr. and the regression explained 82 percent of the within variance.

To determine mean annual sedimentation, the regression coefficients in the above equation were used to correct the periodic measurement to a uniform reservoir capacity (0.20 AF/sq.mi.) and to the long-term average relative peak discharge (1.00). When thus corrected, the sedimentation rates for the three watersheds were 0.016, 0.016, and 0.017 AF/sq.mi./yr. Thus the average annual sedimentation was nearly identical for the three watersheds, instead of varying by 35 percent as would have been interpreted from the means of the unadjusted periodic measurements. The fourth watershed, in which a small burn occurred in 1943, had about double the sedimentation of the others -- 0.036 AF/sq.mi./yr. These results indicate that sediment production from this type of watershed is very low when the forest is in virgin condition. The probability that fire increases sediment production is also indicated.

For the calibration analyses two methods were used. In the first analysis the individual regression equations relating periodic sedimentation to relative discharge and the reservoir capacity of each experimental watershed were used. The analysis indicated that if a treatment doubled the sedimentation it could be detected at odds of 19 to 1. In the second analysis one of the experimental watersheds was used as a control. All periodic measurements of sedimentation were first corrected for differences in the reservoir capacities, using the regression coefficient for "capacity watershed rates" in the above equation. After being thus corrected the relation of sedimentation from watershed 2 to that from 2a, for example, indicated that a treatment which would change sedimentation by as little as 1% could be detected on 19 to 1 odds. Thus, the calibration using sedimentation in one of the experimental watersheds as a control was much better than using the multiple regression as a control. Since only 3 or 4 periodic measurements of sediment were involved in both analyses, too much reliance should not be put on the exact quantities of these estimates. Measurement of sedimentation will continue during the streamflow calibration period.

SAN DIMAS EXPERIMENTAL FOREST

General

A formal inspection of the San Dimas Research Center was made during the period, March 12 to 16, by Director Jemison with Division Chiefs Woolfolk and Colman. This inspection centered upon a review of the research program at San Dimas to explore ways and means of doing a better job.

Streamflow

On January 25-27, 1956 the San Dimas experienced the largest rain storm since December 21, 1954, and the sixth largest since records were started on the San Dimas Experimental Forest in 1933. Precipitation during the storm, as measured at Tanbark Flat, was 10.01 inches, of which 7.06 inches occurred in a 24-hour period. The storm caused considerable flooding in valley areas, but streamflow from adjacent unburned mountain areas was low owing to the initial dryness of the watersheds.

The storm produced peak discharges from the long unburned small watersheds on the San Dimas Experimental Forest which ranged from 1.99 c.s.m. for Fern 3 to 24.8 c.s.m. for Bell 4. Peak discharge from the unburned intermediate watersheds ranged from 5.74 c.s.m. for watershed III (Upper East Fork) to 29.8 c.s.m. for watershed VIII (Bell Canyon). Flows of these magnitudes or greater occur at an average frequency of one or more a year.

In contrast to the small discharges from the unburned watersheds, storm discharge from intermediate watershed I (Wolfskill), partially burned over by wildfire in December 1953, reached a peak of 55.6 c.s.m. A preliminary examination of past records indicates that this peak discharge was approximately 10 times greater than would have been expected had the watershed been unburned. Although the flow from unburned watersheds of the Experimental Forest was comparatively clear, that from the partly burned Wolfskill watershed was heavily laden with mud, rock, and other debris.

Streamflow Calibration Analyses

Analyses of weekly mean streamflow records from Big Dalton watersheds VIII, IX, and X for 15 hydrologic years (1938 through 1952) have been completed for the wetting, percolation, and drying periods. Two calibration (multiple regression) equations have been developed for each hydrologic period for each watershed. One equation is based on meteorological controls alone, and one on a combination of meteorological controls and measured streamflow from check watershed IX. However, considerable work remains in the final checking and testing of these equations, in the interpretation of results, and in preparation of a detailed office report of the analyses.

The above work has been temporarily interrupted in order to take advantage of computing assistance currently available to process records for similar analyses of data from San Dimas watersheds I, II, and III. These analyses will have a twofold objective: (1) to calibrate the watersheds under undisturbed conditions of vegetation cover in order to evaluate effects of experimental treatments or chance changes in watershed conditions upon streamflow, and (2) to determine effects of the 1938 wildfire in watershed II, and the 1952 wildfire in watershed I upon streamflow from these watersheds. A working plan for these analyses has been prepared for staff review.

Preliminary examination of rainfall-runoff records from watersheds I, II, and III indicates water storage capacities are higher in these watersheds than in Dalton watersheds VIII, IX, and X. As a result, a work plan has been prepared for a soil survey to determine water storage characteristics of the soils in the control watershed III. This survey is now in progress. A less detailed examination of the soils in watersheds I and II will also be made to spot any important differences that may exist in the root-zone water storage capacities of the three watersheds.

Rainfall Disposition Study - Tanbark Plots

The semiannual report for April-September 1955 suggested the conditions under which evapo-transpiration from deep soils would be less with grass cover than with brush cover. Invasion of the grass plots by summer-growing forbs during the last year has yielded additional information that requires additional qualification of the results already reported.

All of the plots were originally covered with dense scrub-oak and other native brush. In the winter of 1951-52 the brush on some of the plots was converted to annual ryegrass; the brush on other plots was left undisturbed. During the next two years the grass cover was maintained on the converted plots by killing all brush sprouts, seedlings, and forbs by spraying with 2,4,5-T.

By the end of each of the first three summers of the study the soil beneath the grass cover had dried below field capacity to an average depth of 7 feet and below the wilting point to an average depth of only 3.3 feet. In contrast, each year the soil beneath the brush cover had dried to near or below the wilting point through its entire depth of 12 feet. Consequently, there was a greater carry-over of water at the end of each summer in the soil at depths of 4 to 12 feet under grass than under brush.

In the spring of 1955 the grass plots were not sprayed with 2,4,5-T and the native forbs were allowed to develop without disturbance. As a result, by the end of the summer the soil throughout the depth of 12 feet beneath the grass-forb cover was nearly as dry as that under the brush.

As reported previously, the results of this study indicate that evapo-transpiration from brush- or grass-covered soils less than 4 feet deep would be about the same. Thus, no additional water yield would be expected by converting the cover on these soils from brush to grass. For soils deeper than 4 feet, conversion of brush to grass would result in more water yield in years of rainfall sufficient to wet the soil below this depth. However, recent results indicate that the latter conclusion is true only if the late spring and summer growth of native forbs is controlled.

Instrumentation

Reversal indicators devised by Andrews for the Friez FW-1 water stage recorder have been installed on all instruments of this type in use on the San Dimas Forest. This device employs a special pen that traces along the bottom margin of the chart. The pen changes position when the recorder pen reaches either top or bottom of the chart. If the recorder pen reverses direction with continued rise or fall of water stage, the indicator pen remains in the changed position. If the recorder pen reaches either the top or bottom of the chart, but does not complete a reversal, the indicator pen returns to its original position. This device facilitates the correct interpretation of records obtained with the FW-1 recorder, especially during periods of rapid change in water stage. The reversal indicators were manufactured in Pasadena for about $15 each.

New hard-brass weir plates have been installed on the 90° V-notch weirs at all streamgaging stations currently in operation on the Experimental Forest. This action was necessary as practically all the old weir plates had become somewhat damaged in operation through the years. The new plates were fabricated from 4-inch wide strips of 1/8-inch thick engraver's brass. They have a 3/100-inch cutting edge. Installation was simplified by attaching them directly to the old weir plates. Calibrations of the new weirs indicate that flows fit the Cone formula ($Q = 2.49H^{2.48}$) for heads down to .038 of a foot. For flows of less depth, contraction decreases as the head decreases resulting in a greater flow than indicated by the Cone formula. A formula for the lower heads is being developed.

LOS ANGELES RIVER WATERSHED

Soil Movement Study

Measurements of soil movement were continued at trough installations on slopes in the Arroyo Seco and Upper Big Tujunga watersheds. The third wet season of measurement for the study is now ending. The rate of soil movement continues to be greatest on the rejuvenated slopes at the Lower Brown Canyon sites in the Arroyo Seco. The soils on these slopes are predominantly colluvial. The movement of these types of soil has been found to occur in two principal processes: Active erosion by water during high intensity rains, and dry creep of surface soil during dry weather. Evidence of these processes appears in the following tabulation of data obtained in recent months at the Lower Brown trough sites.

Calendar period	Precipitation (Inches)	Debris collected (Kilograms)	Rate (Kg/day)
October 1 - November 13, 1955	0	1650	38.4
November 13 - December 6, 1955	2.93	930	40.5
December 6, 1955 - January 25, 1956	0.87	287	5.0
January 25 - January 27, 1956	11.17	1814	907.0

During the first period (October 1 to November 13) the soil was moving as dry creep. Intermittent rains fell during the next period to December 6, with some active erosion by water taking place. The soil gained in cohesiveness upon moistening so that during the period of slight precipitation from December 6, 1955 to January 25, 1956 very little dry creep or active erosion by water occurred. The high intensity rain of January 25 to January 27 resulted in water erosion that occurred at a high rate.

Vegetation Study

Seed lots of new species continued to arrive from foreign lands. Following a check of the available literature for descriptions of the species, germination and growth studies were conducted with those species that seemed to best suit our needs. These studies were carried out under temperature conditions comparable to seasonal temperatures occurring in

the local San Gabriel Mountains (see quarterly report October-December 1951). The tests were conducted in the temperature-controlled greenhouses of the Earhart Plant Research Laboratory at the California Institute of Technology.

Germination Studies

Three of nine species received for testing germinated very poorly, five percent or less. Whether the seeds were killed by fumigation when they entered the country or whether they are just dormant has not been determined. Calycotome villosa seed from French Morocco germinated rapidly (six days) under both summer (30°C day, 17°C night) and spring (23°C day, 10°C night) temperature, with an additional delay of six days under winter (17°C day, 4° C night) temperatures. Seeds of the French Moroccan grasses, Festuca elatior and Dactylis glomerata, favored spring and summer temperatures, starting germination within eight days after planting. An additional delay of approximately one week in starting germination occurred under winter temperatures. Oryzopsis miliacea seed from French Morocco gave the highest germination percentage of all seeds tested, but this species also was the slowest to begin germination. Approximately 20 days were required for germination to begin under summer and spring conditions. Germination under winter conditions began 33 days after planting. O. coerulescens started germination under summer conditions within ten days. However, germination under spring and winter conditions was nil reaching a maximum of only three percent in 30 days.

Growth Studies

Three shrubs have been tested since growth studies were resumed last July.

Zizyphus nummularia from India did not survive low winter temperatures of the San Gabriel Mountains, even though these temperatures were several degrees above freezing. The high temperatures of summer did not kill the plants but restricted growth of this species to approximately half that obtained under spring temperatures.

Convolvulus athaeoides from French Morocco was affected quite the opposite by the temperature extremes. The high temperatures of summer killed the plants while the low temperatures of winter only stunted new growth. Temperature also affected the ability of this species to produce a vine. With the low temperatures of winter and early spring the stems did not elongate and were upright rather than in the form of runners. Roots of this species sprouted even under conditions that stunted its top growth.

Salvia mellifera, the native Black Sage, survived and grew under all of the seasonal temperature conditions. Of the three species tested, S. mellifera produced the largest plants (dry weight) under each set of temperature conditions.

MEETINGS

October 18.--Anderson presented a proposal for snow research at a meeting in the State Engineer's office in Sacramento. The State Engineer approved the proposal and outlined methods for obtaining State financial cooperation.

October 20.--Sinclair attended a meeting of the Southern(California) Zone Forest supervisors held at Arcadia. Subjects discussed included Colman's proposal for preplanning for emergency flood prevention and the need for further research in the treatment of burned watersheds in southern California.

October 27.--Rowe discussed "Effects of Population Growth on Local Watershed Management Problems," at a meeting of the East San Gabriel Valley Planning Committee at Covina.

October 28.--Hellmers talked to the Hi-Twelve service club of Alhambra on the subject of "Research in Upstream Flood Prevention."

November 2.--Sinclair attended a luncheon meeting of the Conservation Committee of American Legion Post 13 at Pasadena. Interviews recorded during the meeting were released later over Pasadena radio station KWKW.

November 14-19.--Colman and Sinclair took part in the Forest Service Watershed Management Conference in Denver.

December 2.--Colman and Anderson met with the State Water Resources Board in Los Angeles where Colman presented our proposed snow research program. The Board recommended State financial cooperation in the research.

January 26-27.--Colman presided at one session of the American Geophysical Union's Pacific Southwest regional meeting, which was held in Los Angeles. Sinclair served on the program committee for the meeting.

January 27.--Kraebel spoke to a Bay Area discussion group of industrial research chemists and engineers on the subject, "Watershed Management in Relation to Water Supply and Floods in California." The recent floods in northern California had prompted the group to seek information on flood causes, and flood source areas. More specifically, they were interested in knowing what research was underway to develop methods of flood control in source areas, that would augment the usual downstream control by levees and dams. Considerable discussion was aroused over the possibility of applying techniques of modern chemistry to the improvement of infiltration capacity and soil stability in areas where those characteristics have been deteriorated. What is needed is a treatment that will at once stabilize the soil, restore high infiltration capacity, and yet not seriously retard the growth of desirable vegetation.

February 11.--Sinclair spoke briefly on watershed management research at the annual meeting of the San Dimas Water Company.

February 24.--Colman addressed the Feather River Foresters' Forum at Oroville on the subject, "Watershed Management for Foresters."

March 9.--Colman and Anderson presented the snow research plan at a Station Technical Seminar at Berkeley.

March 14-15.--Anderson attended the California Snow Survey Conference in Redding and spoke briefly on the Station's snow research plans.

March 20.--Zinke and Rowe attended an Irrigation-Water Conference at the Citrus Experiment Station, University of California, Riverside. The meeting was sponsored by the Department of Irrigation at Davis and the Department of Irrigation and Soils at Los Angeles-Riverside for the purpose of acquainting irrigation districts, mutual water companies, water works engineers, managers, and others interested in water problems with the University's program in this field.

March 28-30.--Anderson and Walsh attended a conference at Fraser, Colorado, where Rocky Mountain and California snow research plans were outlined and discussed with Wilm, Storey, and members of the Rocky Mountain Watershed Management Division.

COOPERATION

Bureau of Public Roads, University of California.--Anderson discussed flood analysis methods with William Potter of the Bureau's Washington Office and Prof. David Todd of the University of California.

Fire Division.--Anderson advised Chandler and May on statistical methods relating number of fires to their causes.

Soil-Vegetation Survey.--Colman and Anderson discussed with Gardner and Olson the soil physical measurements needed for watershed management.

Small Watershed Projects.--Anderson and Davidson (Regional Office), with former flood control engineer Amidon, and Flaxman and Beckstrom of the Soil Conservation Service, worked out reservoir design criteria and forest program effects for the Small Canyon and Chino Basin projects in southern California.

Plumas National Forest and Regional Office.--Activities on the Last Chance Creek soil and water conservation project (described in the October 1954-March 1955 Semiannual Report, page 10) were examined by Kraebel in October. Recommendations to the Forest Supervisor were submitted in the form of a series of photographs with comments covering various aspects of the project. These were also discussed in a conference with the Plumas project chief and the Watershed Management Division of the Regional Office.

Humboldt County Department of Forestry.--At the request of Eugene A. Hofsted, County Forester, Colman and Gleason examined the watershed of Bull Creek in southern Humboldt County, studying the relation of land use practices to flood damage in the area. Results of the field examination were presented orally and discussed at a meeting of the Humboldt County Forestry Committee in Eureka on March 8.

Los Angeles County Flood Control District.--W. R. Ferrell, in charge of the new Debris Reduction Study Group, Los Angeles County Flood Control District, and Reinhold Nagel, engineer in the group, discussed progress and future plans of the study group with Rowe.

Supervisor Mendenhall, Colman, and Sinclair met with Baumann, Laverty, and Ferrell of the Los Angeles County Flood Control District on January 24 to discuss the District's application for a small watershed flood prevention program in Monroe Canyon.

Corps of Engineers, U. S. Army.--Data on probable peak discharge and erosion rates, following fire, for Cable, Devil and East Twin Creek watersheds, together with other information on floods and erosion in southern California watersheds were supplied Mr. Lloyd H. Fitts, Acting Chief, Engineering Division, Los Angeles District.

Angeles National Forest.--Rowe, with Myles R. Howlett, Clifford A. Davidson, and William L. Minaker, inspected sites for channel stabilization structures in Cooks Canyon of the Los Angeles River drainage.

Hellmers inspected the La Tuna burn of 1955 in the Verdugo Hills area with personnel from the Angeles National Forest and the Los Angeles County Forester and Fire Warden Department. A sowing of mustard and ryegrass was recommended for the ridges and firebreaks within this 4,000-acre burn. All of the burn is outside of the National Forest but in the Los Angeles River drainage.

Adams & Ells, Engineering Division of Ells Inc.--William C. Ells called at the office to discuss and obtain peak discharges and erosion rates for use in planning flood and erosion control measures for the areas below Maddux Canyon.

Conservation Association of Southern California.--Colman and Sinclair met with a small committee from the Conservation Association of Southern California to discuss the proposed program of watershed management research in southern California to be conducted in cooperation with the State Division of Forestry.

Northeastern Forest Experiment Station.--Specifications and a drawing of the San Dimas precipitation weighing balance were sent to the Laconia Research Center.

Rocky Mountain Forest and Range Experiment Station.--Information about the San Dimas vectopluviometer was sent to the Division of Watershed Management.

Coweeta Hydrologic Laboratory.--Rowe served as a member of a board of review for the proposed publication "Effects on Streamflow of Cutting a Forest Understory" by E. A. Johnson and J. L. Kovner.

Division of Flood Prevention and River Basin Programs (U.S.F.S.).--Marvin J. Rosa was given data on hydrologic characteristics and behavior of southern California mountain watersheds for use in the small watershed program.

Institute of Forest Genetics, California Forest and Range Experiment Station.--Hellmers discussed with Robert Z. Callaham the possibility of using the Earhart Plant Research Laboratory for part of a study on causes of dormancy in ponderosa pine.

VISITORS

October 13-16.--Dr. Franz Hartmann, Director of the Institute of Forest Soils, College of Agriculture, Vienna, was conducted by Kraebel across northern California, to examine forests and soils from the Coastal Redwood Region to the Great Basin. Soil-vegetation surveyors Zinke and Olson joined the party in the coastal and central valley areas, respectively, to explain the local soils and survey techniques.

There have been about 100 visitors to the San Dimas Experimental Forest during the past 6 months. Included was the U.S.D.A. Advisory Committee on Soil, Water, and Fertilizer; the Hydrology Subcommittee of the Pacific Southwest Inter-Agency Committee; members of the Citizens' Forestry Study Group of San Diego County; and a hydrology class from the California Institute of Technology. Foreign visitors came from Kenya Colony, Israel, Japan, and Pakistan.

SEMIANNUAL REPORT ON FOREST WATERSHED MANAGEMENT

Central States Forest Experiment Station

Athens Research Center

October 1955 -- March 1956

General

Division status has been approved for watershed management research in the Central States. It is expected that the division chief position at the Columbus office of the Central States Forest Experiment Station will be filled before July 1, 1956.

The winter season has been chiefly devoted to the analysis of data. Preliminary analysis of a portion of the soil-site and soil moisture data was made so as to determine trends and general relationships.

Soil moisture measurements from undisturbed and clearcut hardwood plots at the Vinton Furnace Experimental Forest were discontinued in November and the data from this study is now being assembled and analyzed. Plans are being made for additional soil moisture studies under pine, broomsedge, and brush (sassafras, hawthorn, crabapple) covers.

Meetings

In January, W. H Carmean attended the annual meeting of the "North Central Region Technical Soil Survey Work Planning Conference" held at East Lansing, Michigan. This group is composed of the Soil Survey technicians from the Central and Lake States who meet annually to review, plan, and coordinate regional soil survey procedures. Carmean was a member of a committee that reviewed the use of soils information in forestry work. Recommendations were made on how present soil survey information could be used and how future surveys could be altered so as to supply information useful in forestry programs.

H. C. Storey, Director McGinnies, and Carmean attended the Agricultural Research Service Soil and Water Work Planning Conference held March 1-2 at Coshocton, Ohio. Watershed conditions of southeastern Ohio related to land use and vegetal cover were inspected enroute to the conference.

In April, W. H. Carmean will present two informal papers at the annual meeting of the Ohio Academy of Science. One paper will be a preliminary report on the relation of water infiltration with land use and physical soil conditions. Results of this study were summarized in the last watershed management semiannual report (April - September, 1955). The second paper will present preliminary results of our black oak soil-site studies relating site quality to various conditions of soil and topography.

Current Studies

Surface water runoff measurements from undisturbed oak forest, clearcut forest, and abandoned fields are continuing. Analysis of data from this study is planned for next fall and winter.

Soil moisture measurements from undisturbed oak forest and clearcut forest plots were discontinued in November. The data from this study is now being analyzed.

Additional soil moisture studies are proposed for initiation in April. Gravimetric soil samples will be taken from: (1) undisturbed oak forest; (2) young natural old field shortleaf pine forest; (3) clearcut pine forest; (4) abandoned agricultural land now in broomsedge cover; and (5) abandoned agricultural land that has succeeded to a cover of sassafras and hawthorn. These studies are designed to measure seasonal soil moisture levels associated with these varied conditions of plant cover that are typical of the vegetation of southeastern Ohio.

Cooperative Studies

The Ohio State Division of Water is cooperating in the measurement of ground water levels on the Vinton Furnace Experimental Forest. Six shallow ground water wells have been established. Three of these wells are in undisturbed oak forest and three are in a clearcut area.

The Soil Survey of Ohio has recently become interested in the soil-site work now being conducted with upland hardwoods. The Soil Survey of Ohio is jointly conducted by the Ohio Division of Lands and Soils and the Soil Conservation Service. Presently established soil-site plots are being visited and identified as to site index and soil series as mapped by the Soil Survey. The Soil Survey hopes to be able to classify land in terms of forest productivity as well as for agricultural productivity. Long-range objectives involve the ability to prescribe better land use for southeastern Ohio.

Black oak site quality in southeastern Ohio is related to physical soil conditions and topography

A preliminary analysis of the initial data from black oak site plots has been made to determine general trends and relationships. Graphical analyses and simple correlation analyses between site index and several soil and topographical features revealed the following relationships:

(1) Site quality for black oak increases as the depth of A horizon increases. Site index decreases as clay content of all soil horizons increases. These relationships are significant at the 5 percent level, even though the statistical analysis consisted of single variable correlations.

(2) Graphical analyses indicated that site index decreases as moisture equivalent and gravel content of all horizons increases. Site index also increases with increasing sand content of all horizons. The best sites are usually found on east aspects and on lower slopes and the poorest sites are usually found on west aspects and ridges.

(3) The above are general relationships supported by only limited preliminary analyses. Final conclusions will be based on many field plots with data analyses made by standard multiple regression techniques. It is of interest, however, that these preliminary analyses indicate such close agreement between site index and various single variables of soil and topography.

SEMIANNUAL REPORT ON WATERSHED MANAGEMENT RESEARCH
Intermountain Forest and Range Experiment Station
October 1955-March 1956

GENERAL

Rain-on-Snow Floods. Damaging floods occurred on the Truckee River in Nevada, and on several major streams in southwestern Idaho, late in December, as a result of heavy rainfall on snow. New snow following the rain prevented more than cursory inspection of the flood-source areas. However, enough was observed to reveal some interesting watershed management aspects of the flood control problems in both localities.

The 1955 flood on the Truckee came just 5 years after a similar event in 1950. During the interval there has been much interest in a proposed dam and storage project on one of the major tributaries. The latter tributary did not contribute any substantial amount of runoff to the most recent flood. The bulk of the damaging portion of the runoff came from the main stem on which are no flood control structures, and on which none is proposed. This, coupled with the knowledge that the plant and litter cover on parts of the watershed is in a greatly depleted condition, has stimulated interest in the possibility of improving control of runoff by watershed management, and in the need for research to find out where and how to accomplish that objective.

The winter floods on the Boise, Payette, Little Salmon, and Salmon River tributaries, are known to have originated mainly on mid-elevation lands including foothill bunchgrass slopes, old burn brush lands, and adjoining ponderosa pine lands. The 6 to 10 inches of rain that fell in this belt was sufficient to melt most of the snow that had accumulated and to cause runoff by quick seepage over extensive areas. The runoff, in addition to causing much channel cutting, also caused slumping and gullying in many drainage bottoms and side slopes, thereby adding unusually large amounts of sediment to the main streams. The fact that gullying occurred on areas having essentially normal plant cover conditions, as well as on those obviously disturbed by road building, logging, fire, and grazing, points up the instability of the granite soil mantle in that area. Further study of the flood-source areas is planned with a view toward determining the extent to which poor watershed management practices aggravated flood runoff and sediment production.

More floods expected. Record-breaking and near-record snowpacks pose a threat of snowmelt floods this spring on many of the Columbia River tributaries in Montana, Idaho, and Wyoming. Whether floods actually occur will hinge on a buildup of high temperatures, the occurrence of warm rains, or a combination of both. Emergency flood control work is now under way on many of the streams.

Drought in Southern Utah. In contrast to the abundance of water in the northern portion of the Station territory, southern Utah appears to be faced with a water shortage comparable to the drought in 1934. Runoff in the Sevier River basin has been below normal in 6 of the last 7 years. Holdover storage is nearly exhausted in most of the reservoirs, and snow surveys indicate runoff this year will be far below normal again. The impending water shortage has provoked keen interest in the difficult problem of finding ways and means of increasing water yields from the watershed lands, while at the same time providing adequate control of storm runoff and sediment production.

Meetings. Following the Watershed Management Conference in Denver, Bailey, Craddock, and Packer, met with the Regional Forester, his staff, and representatives of all the forests in Region 1 at Missoula, to consider the nature and priority of watershed management problems in that portion of the Station territory. The 3-day session provided a good basis for coordinating the research needs in that area with going work in the Region 4 portion of the Station territory.

In January, Craddock attended the annual meeting of the American Society of Range Management in Denver and gave a paper on "The Place of Forestry in Watershed Management."

In March, Craddock met with the Sedimentation Subcommittee of the Pacific Southwest Interagency Committee in Los Angeles and presented a report on the watershed management action and research programs of the Forest Service in the committee territory.

Late in March, Craddock attended the annual meeting of the Intermountain Section of SAF at Provo, Utah, and gave a paper on watershed research.

Personnel. Richard O. Meeuwig joined the staff in December by transfer from the St. Joe National Forest. He has been assigned to the Wasatch Research Center to assist Marston.

Howard K. Orr is scheduled to transfer from the Great Basin Research Center to the Black Hills Research Center early in April. A replacement for Orr is needed. Any takers?

BOISE RESEARCH CENTER

Soil Disturbance by Logging. Last fall a survey was made of the areal extent of soil disturbance that was caused by the 1953 and 1954 ponderosa pine harvest cuttings on 16 compartments in the Boise Basin Experimental Forest. The survey data were subjected to regression analysis to determine the extent to which soil disturbance was affected by stem ~~collection~~ selection and group selection of trees, and by the use of large and small logging tractors. The number of trees harvested was used as the independent variable in all analyses.

The area of soil disturbance increased significantly with intensity of harvest cutting under both systems of tree selection, though the greatest increase in soil disturbance occurred under stem selection (Fig. 1).

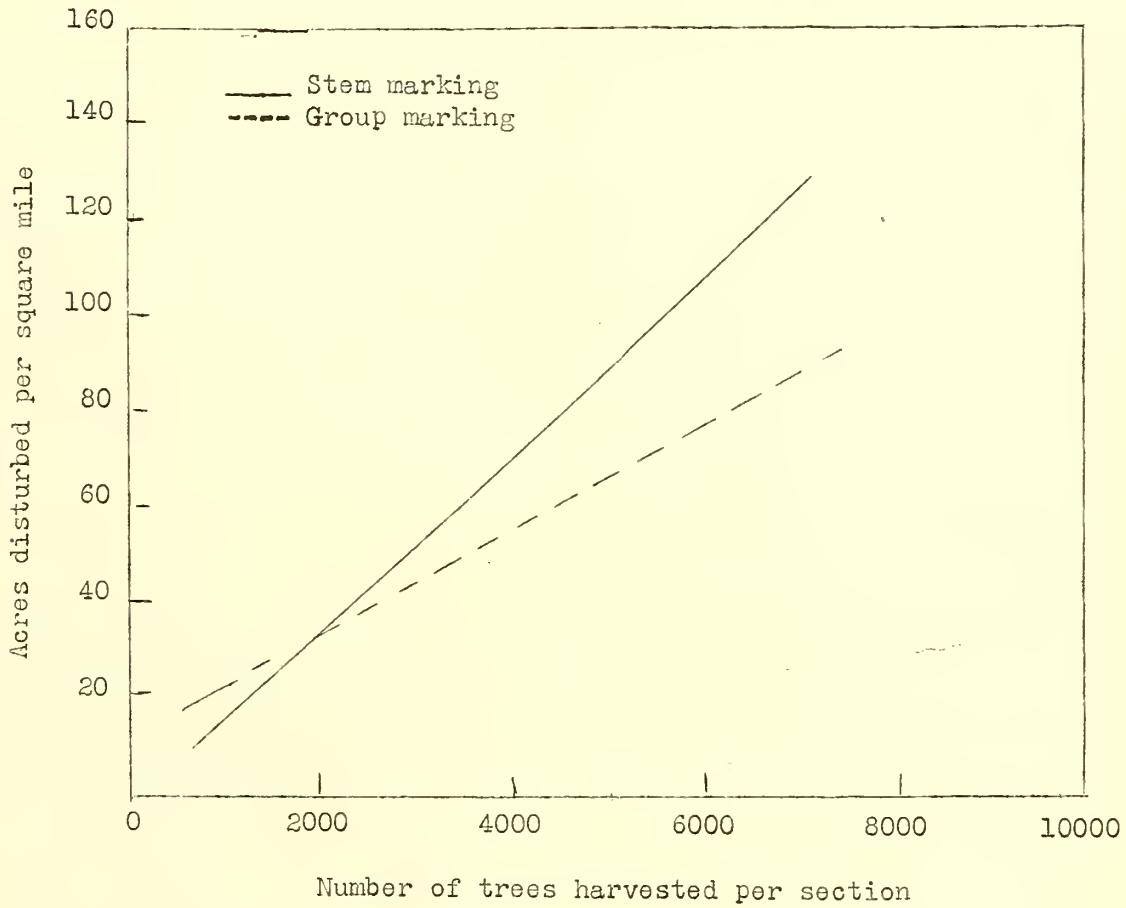


Fig. 1.--Relation of soil disturbance to intensity of harvest cutting under two systems of ponderosa pine selective cutting

Harvesting 2,000, 4,000, and 6,000 trees per square mile under the stem selection system caused soil disturbance on 6, 11, and 17 percent of the area, respectively. Soil disturbance ranged from 5 to 12 percent under similar intensities of cutting by group selection (Table 1).

Table 1.--Extent of soil disturbance under different systems and intensities of ponderosa pine harvest cutting

Trees harvested	Soil disturbed	
No./Sq.Mi.	Acres/Sq.Mi.	Percent
	Stem Selection	
2,000	36	6
4,000	72	11
6,000	108	17
	Group Selection	
2,000	33	5
4,000	55	9
6,000	77	12

In compartments cut under stem selection and which were logged by small tractors, the amount of soil disturbance caused by haul roads increased with intensity of cutting whereas the amount of disturbance caused by skidtrails remained about constant. On compartments logged with large tractors, there was no significant increase in soil disturbance with increased intensity of cutting, but there was a significant increase in soil disturbance by skidding (Fig. 2).

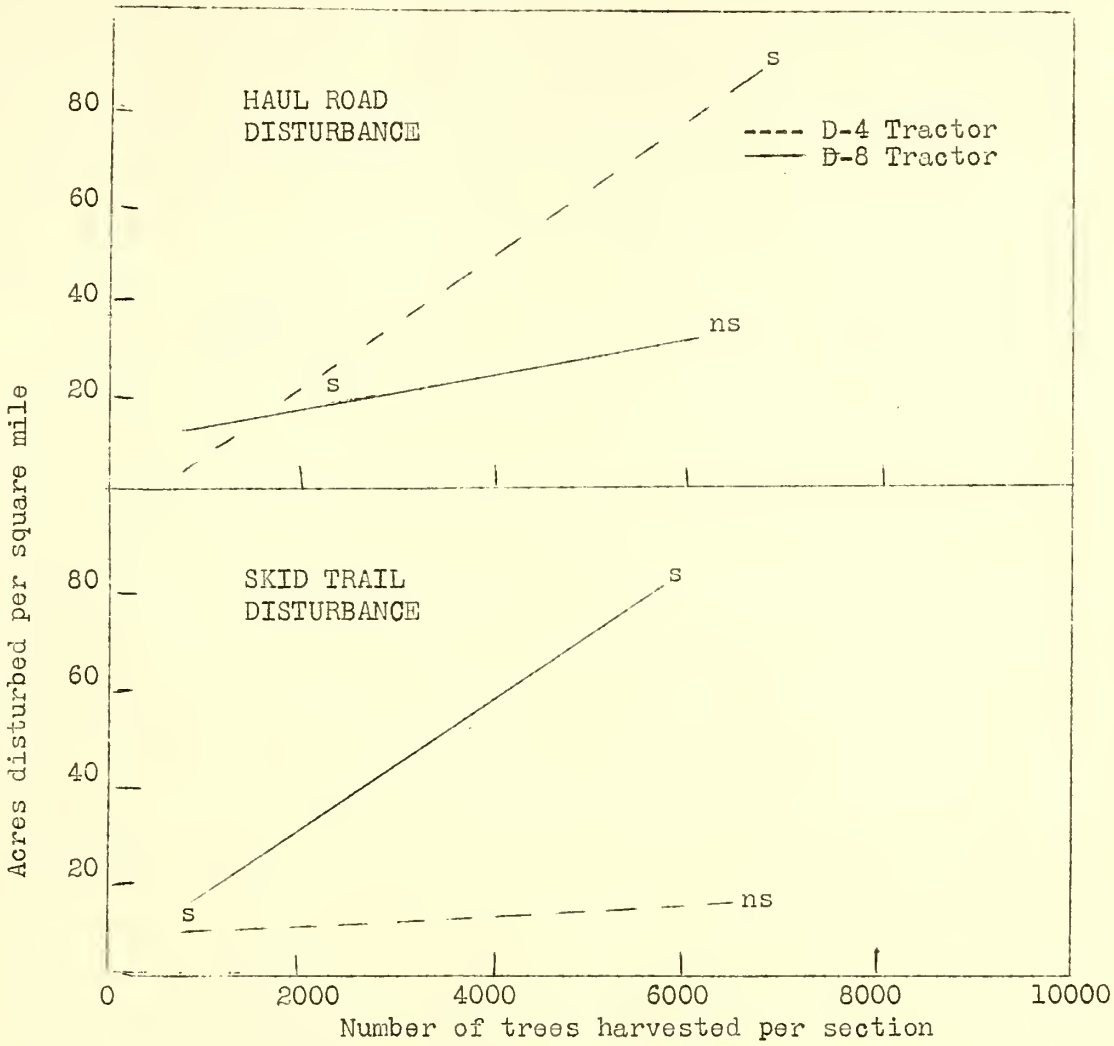


Fig. 2.--Effects of large and small logging tractors on the relation of soil disturbance from haul roads and skidtrails to the intensity of harvest cutting ponderosa pine by stem selections.

On group selection compartments, soil disturbance from roads did not vary with intensity of cutting where logging was done by small tractors. On similarly marked compartments where large tractors were used, soil disturbance from roads increased significantly with intensity of cut, the amount of disturbance exceeding that caused by small tractor with removal of more than about 5,750 trees per square mile. Soil disturbance from skidtrails increases significantly with intensity of harvest cutting and at essentially the same rate on compartments logged by small and large tractors (Fig. 3).

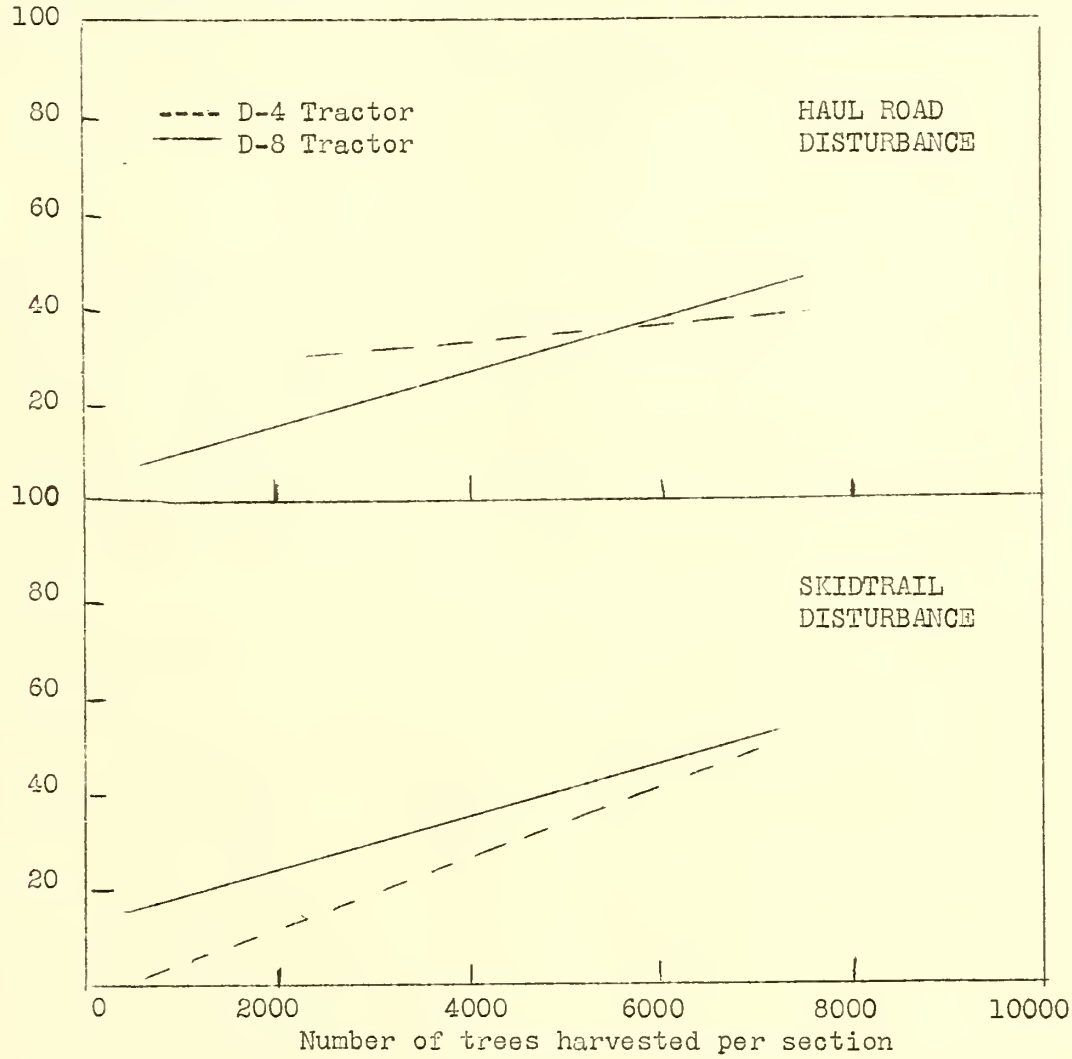


Fig. 3.--Effects of large and small logging tractors on the relation of soil disturbance from haul roads and skidtrails to the intensity of harvest cutting ponderosa pine by group selection.

Thus far, sediment has been trapped in debris basins on 4 of the 16 compartments. It has also been observed to be in transit in measurable amounts on 9 of the compartments. More time will be required to determine which marking method and size of tractor will be best for minimizing sediment production. However, if the data on soil disturbance are indicative of potential sediment production, it appears that stem selection marking and logging by a small tractor is the least desirable combination because it caused the most extensive soil disturbance.

Haupt has submitted an article on "Nitrogen Loss from Granitic Soil on Cheatgrass Brome Ranges" to Forest Science.

WASATCH RESEARCH CENTER

Sediment Production Rates. The rapid expansion and mounting costs of water storage projects in the Station territory has aroused new interest in the problem of controlling and preventing accelerated erosion on tributary watershed lands. A recheck on the sediment production rates of several of the subwatersheds in the Davis County Experimental Watershed justifies this concern. On 6 of the watersheds where headwater lands had been damaged by overgrazing and fire, sediment production has been averaging from 1.58 to 9.01 acre feet per square mile of watershed per year. These rates are from 608 to 3,465 times greater than that from the undamaged Morris Creek watershed (Table 2).

Table 2.--Sedimentation rates of some Davis County Experimental Watershed drainage basins

Drainage basins	Period of record	Sediment production	
		Total	Rate
	Years	A.F.	A.F./Sq.Mi./Yr.
Parrish	17	330	9.01
Barnard	24	53	1.58
Ford	24	185	3.27
Davis	24	125	3.31
Steed	24	191	2.88
Farmington	24	578	2.44
Morris	9.2	.0063	.0026

Air Movement. Anemometer records taken at the Parrish Plots in the summer of 1948 as part of an evapo-transpiration study were analyzed to determine some of the characteristics of air movement under an aspen canopy and on an adjacent opening. The analysis showed total air movement for the season to be about 4.5 times greater in the open than under the aspen. Average velocities were also consistently greater in the open than under the aspen throughout the period of record (Table 3).

Table 3.--Velocity of air movement under aspen and in the open, Parrish Plots, 1948

Period	Velocity		Reduction	
	Open	Aspen		
	m.p.h.		m.p.h.	percent
July	3.62	1.00	2.62	72
August	3.11	0.54	2.57	83
September	3.02	0.44	2.58	85
October 1-13	3.61	1.15	2.46	68
July 7-Oct. 1	3.16	0.51	2.65	84
July 1-Oct. 13	3.29	0.72	2.57	78

Further analyses showed that the correlation of actual reduction with velocity in the open was direct and highly significant. This is in agreement with Kittredge's conclusion that "The reduction of actual velocities in the canopy and below it is greater in strong than in light winds." It also showed that the relation between relative reductions and velocities in the open was inverse and highly significant. This does not agree with the second part of Kittredge's conclusion that "The relative reduction varies little with velocity." One possible explanation for this disagreement is the lack of high velocities in the sample. None of them exceeded 6 m.p.h.

Marston has submitted a report on this study to the Journal of Forestry.

Spurious Correlations. Marston offers the following comments on Milton T. Wilson's and Eugene L. Peck's "Discussion of 'The Effect on Stream Flow of the Killing of Spruce and Pine by the Engelmann Spruce Beetle' by L. D. Love.":

Dr. Love showed a significant time trend increase in streamflow from White River watershed by use of a multiple regression equation. He used two independent variables, X - was annual flow of Elk River, and X_2 was difference (Elk minus White) in the April water content of snow on the two watersheds.

In their discussion of this analysis, Messrs. Wilson and Peck suggest that additional climatological data, including fall and spring precipitation, be used to develop a seasonal index of precipitation. That is a logical procedure and its effectiveness is shown in the higher correlation 0.87 against 0.76 for water stored in snow only. This correlation might be improved even further if proper weights were assigned to the various fractions of precipitation.

Wilson and Peck go one step further and suggest: "If the time trends can be accounted for by indices representing antecedent conditions then the increased streamflow reported by the author would not be due solely to the death of the trees. As an index to the carry-over effects, base streamflow during a winter month may be used."

Is this logical? No doubt streamflow is related to antecedent conditions but what is affecting the antecedent conditions? Also, is it legitimate to use base flow during a winter month as part of the independent variable? Isn't this combining part of the dependent variable with the independent one? Doesn't this induce correlation that obscures the effect of treatments?

Parrish Creek Streamflow Station. Construction of the Davis County Aqueduct (part of the Weber Basin Project) across Parrish Creek near the boundary of the Davis County Experimental Watershed has necessitated the reconstruction of a new streamgaging station. A good site for the new structure was found a few hundred feet above the aqueduct crossing and plans for the new installation are now nearing completion. The new installation will include a debris basin for trapping bedload above the weir pond.

GREAT BASIN RESEARCH CENTER

Manti Reseeding Evaluation Study. In 1952 several hundred acres of subalpine-herbaceous range in the head of Manti Canyon on the Manti-LaSal N. F. were plowed and seeded to grass. Last fall, records of runoff, erosion, infiltration, and forage production, were obtained from 4 plots on each of 4 pairs of treated and untreated sites in the range improvement project area.

Total ground cover, including live plants and litter, average 65 percent on the treated plots and 70 percent on the untreated areas, a difference that is not statistically significant. However, treatment drastically changed the composition and volume of forage production. There was about 5 times more grass and 40 percent as much forb cover on the treated sites than the untreated areas. Forage production on the treated sites (1,551 pounds per acre) was about twice that (848 pounds per acre) on the untreated sites.

On the average, overland flow, erosion, and infiltration rates did not differ significantly between the treated and untreated sites. However, the data showed that runoff and erosion decreased with increased amounts of ground cover and that there was an inverse relation between ground cover and infiltration. Infiltration rates on areas having above average ground cover were about 2 times greater than those having below average ground cover. There also was a tendency for infiltration rates during the first 20 minutes of applied rainfall to be greater on the treated plots than on the untreated areas (Fig. 4).

It is expected there will continue to be further changes in both the composition and the density of the vegetation on the treated sites, as the newly established grass plants become more vigorous. Additional tests on the treated and untreated sites are planned for the future. It is also planned to introduce the effects of grazing into the study as an additional variable.

Pleasant Creek Watershed Evaluation Study. Last fall the first set of information on forage production and hydrologic characteristics was obtained on several flood-source areas in the Pleasant Creek Watershed near Mt. Pleasant, Utah. The data were obtained immediately prior to the application of watershed improvement measures, including protection from grazing, artificial reseeding, and contour trenching. A progress report on the initial phases of the study is now nearing completion for distribution to the cooperators involved in the watershed restoration program. The plan calls for repeat measurements in 1958.

Streamgaging Stations. Plans have been drawn up for converting the present flume-type streamgaging stations on the Alpine Cattle Pasture and Left Fork watersheds in the head of Ephraim Canyon to weir-type installations. The change is necessary to improve the accuracy of low flow measurements and to provide a basin for trapping and measuring sediment production.

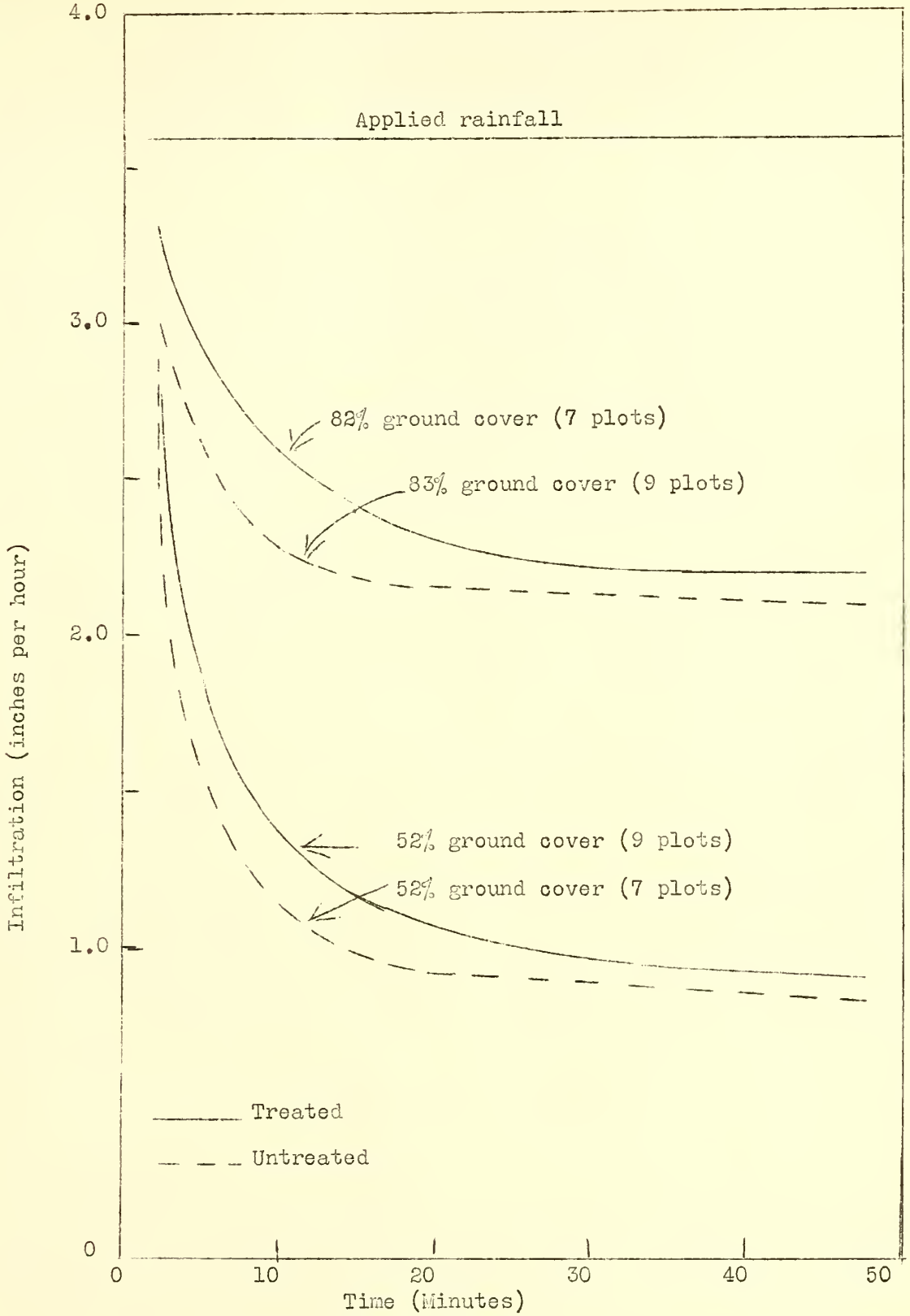


Fig. 4.--Average infiltration curves for treated and untreated plots with ground cover densities above and below average.

NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report April 1956

GENERAL

This last six months went by in about six weeks. Specific accomplishments are given in Irv Reigner's, Sid Weitzman's, and Dick Trimble's reports from their respective centers. Viewing their work from the elevation of Upper Darby (whose altitude is a few hundred feet lower than most everything in the Northeast) gives a more diffused perspective. Viewed thus, at Kingston, Reigner and Eschner are concentrating on calibration of Dilldown and preparation of a number of papers from Dilldown data before turning their attention to development of a research program of greater scope in their area. For this latter objective, a problem analysis was worked out and given Washington office, Region 7, and in-Station review.

At Mountain State, Sid Weitzman, Ken Reinhart, and Burley Fridley are also juggling calibration data, and are launching into new work. The Fernow's five watersheds were increased to seven last fall and two more will be added this year. On-watershed plots studies of soils and soil-moisture under calibration conditions are being started.

Trimble, Sartz, and Pierce keep busy doing at one and the same time the job of problem analysis and program development, building weirs, and initiating first studies of White Mountain factors influencing streamflow.

A number of papers involving assistance from Upper Darby have reached and lingered in the rough-draft stage since our last report. These include a report on results of our soil moisture study at the Lebanon Experimental Forest in New Jersey, a review of literature on forest and range soil compaction, a comparison of streamflow from essentially forested and cropland watersheds using Geological Survey data, and a review of the role of forest humus in watershed management.

KINGSTON RESEARCH CENTER

How Rainfall Affects Groundwater

Ordinarily, in this region of well-distributed rainfall, groundwater levels follow a nice routine. They are high during the winter, fall during the summer and early autumn, then begin to rise after leaf fall and the coming of cooler weather.

But during the past eight months, this pattern has been almost reversed, the result of rainfall which has NOT been well distributed. Early last August, groundwater was normally low for that time. Along came those two wet hurricanes, Connie and Diane, which dumped tremendous quantities of water on the Pocono Mountains. Consequently, groundwater rose to the extreme high levels usually attained after heavy winter storms. So groundwater remained high during late summer and autumn, reaching a record high in October after another large storm.

Then, however, rainfall slacked off--November was drier than normal and during December was a record low, less than 3/4 of an inch in the Poconos. January was also very dry, about 1½ inches. As a result, by the beginning of February, groundwater had fallen to low levels expected only during the summer months. Since then, there has been considerable snow and rain, raising groundwater to normal spring levels.

This has been an excellent example of the way groundwater is influenced by rainfall.

Watershed Calibration

Although harassed by the numerous reports, performance ratings, and other deadlines that occur in the first quarter and which appear to be so unfruitful to a researcher, we were able to devote a considerable amount of time to the calibration analysis of the Dilldown watershed. We have made a rather thorough study of the monthly relationships discussed in the previous quarterly report. Many ideas and admittedly numerous blind alleys were investigated as completely as possible. Progress in improving the relationships has been gradual but continual - a very gratifying situation.

One of the things we found is that average monthly temperature is better related to monthly streamflow than is monthly saturation deficit. Although theoretically the latter should have more influence than straight temperature, statistically the temperature factor removes considerably more of the variation.

It was also discovered that the combination of the three independent variables, monthly precipitation, antecedent precipitation, and a temperature factor resulted in a curvilinear expression of monthly runoff. This curvilinearity was removed by putting the dependent variable on a log scale. Although the relationship was considerably improved, the logarithmic expression of the dependent variable caused certain disadvantages, particularly in expressing the standard error of estimate.

As the latter is a very necessary product of this analysis, we searched for a method to eliminate the curvilinearity. None of the independent variables appeared to have a curvilinear effect, but a ratio interaction, Precipitation/Temperature, straightened the relationship and furthermore eliminated the precipitation term.

We are at this point at present, and have attained a standard deviation from regression of 0.37 inch. We feel certain this can be refined still further.

Physical Properties of Some Northeastern Soils

A rough draft of a station paper summarizing the physical properties of some northeastern soils, studied by the Vicksburg Infiltration Project, has just been completed by Art Eschner. In addition to presenting the data in a table, he has tried to uncover some relationship between bulk density and texture and organic matter content. Organic matter content appears to be strongly correlated with bulk density; clay is of less importance; and sand even less.

Scrub Oak Conversion

Plans are all set for the planting of the 35 acre area on the Dilldown watershed that was prepared last fall by root rake.

From time to time, various interested persons have suggested the use of explosives to prepare planting sites in scrub oak areas. Their idea was to blow out the scrub oak crowns and expose mineral soil in planting spots or in strips. Accordingly, the idea was investigated in January. A thin layer of frost, one to two inches thick, was considered more help than hindrance, thinking that a greater surface area would be exposed. Unfortunately the experiment was not successful. The holes produced by the explosion were too deep and not large enough in area; the finer soil particles were lost and the rocks remained. Even had the planting spot been suitable, the time involved in placing the explosives and stringing the wires would make the procedure impractical.

Visitors

With just a one-day notice, Reigner was asked to show a group of U. S. Geological Survey men around the Dilldown project. Those attending were Jim Culbertson, Engineer in Charge of the Water Quality Branch in Philadelphia, and W. V. Irons, Rivermaster of the Delaware River at Milford, Pa. Malcolm P. Crooks from western New Jersey also attended the trip.

MOUNTAIN STATE RESEARCH CENTER

Soil-Moisture Study

A working plan has been prepared for a soil-moisture and humus study to start this spring on our 5 gaged watersheds. Our main objective is to gather information to assist in interpreting any changes in stream-flow measured at the weirs after the watersheds are cut according to different practices. Soil moisture will be measured gravimetrically in this study.

Analysis of Calibration Period

A major problem at the moment is to determine when we can start cutting in the gaged watersheds. Analysis of stream-flow by months shows very good correlation between watersheds to be treated and the control and also appears to indicate that our calibration period (5 years) is now long enough. However, we are aware of the time-series objections to the use of monthly data. In so far as low discharge values are followed by low values because of a holdover effect from month to month, such objections appear valid and important. However, in so far as low values are followed by low values because 2 consecutive months both have low precipitation and high evapo-transpiration, the objections seem to lose much of their importance. Perhaps a statistical method can be devised to take the above factors into account. Any suggestions? We have a date in late April to talk this over with Hal Wilm.

Open-Land Watersheds

There are over 1½ million acres of open land in West Virginia which should go back to trees. Two small abandoned-pasture watersheds, typical of this area, have tentatively been selected for study. During the calibration period, these watersheds will reveal the runoff characteristics of pasture as compared to forest land. Then emphasis will shift to determine the time it takes to rehabilitate such areas and the magnitude of changes in watershed characteristics brought about by rehabilitation.

Water Quality

Our studies of water quality, especially turbidity, are continuing. It becomes increasingly clear that stream turbidity is often seriously affected by material from road runoff long before the usefulness of the road is impaired.

Computations

One objective on the Fernow has been to keep streamflow and precipitation data computed and checked to within three months of the date collected. Burley Fridley, Forestry Aide, has for years been doing a fine

job of meeting this difficult but worthwhile objective. At the moment, due to pressure of events, we have temporarily, we hope, fallen slightly behind this objective. We believe that a policy of keeping abreast of computations and analysis is worth the struggle necessary to accomplish it.

WHITE PINE-HARDWOOD RESEARCH CENTER

As of the first week in April the Hubbard Brook Experimental Forest is still buried under a heavy blanket of snow. At elevations of 2500', a foot of snow water is lying on top of the ground. There is less at lower elevations but all over watersheds of the North Country hangs an ominous flood threat. A week of warm sunny days and cold nights could move a lot of snow water safely down the brooks, but a heavy rain at this time could trigger raging torrents. Fortunately, there is little, if any, concrete frost in the woods and not too much in open areas.

Throughout the winter we have carried on snow and ground freezing observations at Hubbard Brook in conjunction with the runoff and precipitation studies on the gaged watershed. We found, as was expected, that snow survey data could not be substituted for winter precipitation measurements in this country. "January thaws" and occasional rains throughout the winter period preclude total dependence on snow surveys. This winter, for example, about the middle of January we lost practically all of our snow below 2000 feet elevation. In that month we had several inches of precipitation in the form of rain. The weather got so warm that all of the ice went out of the pond behind the weir--and it was a foot and a half thick.

Our weir has given a continuous and excellent record of streamflow throughout the winter months. The only winterizing we have done is to use an oil tube for the float. Weekly we cut the ice back in a 2-foot semi-circle behind the V-notch to make sure of unimpeded flow when we checked the stage height on the chart. At times of extreme cold--subzero weather--flow over the notch was temporarily distorted by ice blocking or draw-down. These conditions shortly corrected themselves and chart corrections were simple and obvious.

We used Prestone to prevent freezing in our rain gages. This is easier to use and gives a more dependable and predictable protection against freezing than calcium chloride. We use oil for protection against evaporation. All winter precipitation measurements are made by weighing the catch.

Talks

Pierce presented a paper on the effects of land use on ground freezing in the Northeast to the annual meeting of the Eastern Snow Conference at Dartmouth.

Jensen and Trimble gave a radio talk in Greenfield, Massachusetts on the different aspects of watershed management in New England.

Trimble discussed watershed management problems before the annual meeting of the Massachusetts Forest and Parks Association in Boston.

Papers

"Snow storage and melt in a northern hardwoods forest" by Sartz and Trimble has been submitted for publication in the Journal of Forestry.

Visitors

George S. Cavadias, Hydrologist for the Shawinigan Water and Power Company in Montreal, Canada, spent a day in Laconia discussing the effects of land use on streamflow. The Shawinigan Company has large timberland holdings in their watersheds. This company is desirous of managing these forested watersheds to obtain optimum effects on streamflow. In their reservoir-building program they are aiming at a better distribution of flow throughout the year. They are studying ways of land use management to supplement their construction program.

PUBLICATIONS

Research on the Fernow Experimental Forest by Sidney Weitzman. Northeastern Logger 4(7): 14-15.

Chaff Seeding - One Answer to Soil Washing on Logging Roads by G. R. Trimble, Jr. and Sidney Weitzman. West Virginia Conservation 19(12): 12-13.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Watershed Management Research
Semiannual Progess Report, October 1, 1955 - March 31, 1956

General

One of the principal efforts during the last six months has been the recruitment of personnel for vacancies in our new Division of Watershed Management Research. We have run into problems common to all parts of the country, but have finally succeeded in filling all positions.

A second important project has been the completion of negotiations for two cooperative projects. These will serve to broaden the scope of our watershed management research program in the Pacific Northwest. In both cases the cooperators have contributed cash for the employment of technical personnel. It has been gratifying to realize that interest in watershed research has been sufficient to prompt this type of support.

Willamette Research Center

On the H.J. Andrews Experimental Forest, debris basins were completed on each of the three experimental watersheds. They have been designed to trap bed load only and accumulations from year to year will be determined by profile measurements within each catchment area. These data will be supplemented by samples of suspended sediment which escapes the debris basins at the spillway. Arrangements have been made for analysis of these streamflow samples at Oregon State College. Principal determination will be concentration of solids in suspension. We plan, in addition, to determine particle size distribution for randomly selected samples.

Work was started on a backlog of streamflow records from the three small watersheds. Daily average head was determined by a visual method similar to that used by the U.S.G.S. Conversion of head to discharge has been postponed for another year during which we hope to increase the reliability of our stage-discharge rating curves.

Mid-Columbia Research Center

David D. Wooldridge reported for work in Wenatchee in February. Wooldridge was formerly employed by Rayonier, Inc. as a research technician engaged primarily in soil investigations. His experiences in this field have qualified him for the type of activity which we plan to undertake in the Mid-Columbia area.

One of his first jobs is to prepare a project analysis of soil problems in the Mid-Columbia province. A good basis for this analysis is being established by John Arnold (Engineering Division, Region 6) who has classified the surface geology and land forms in the national forests of Washington. Purpose of Arnold's project is to determine surface characteristics which will influence plans for roads and other types of land use. We hope to supplement his basic information by classifying the land types of the Mid-Columbia area with respect to their influence on water yield and water quality.

The addition of watershed management activities in the Mid-Columbia Center has necessitated additional office and laboratory facilities. Arrangements for space have been made with the Washington State Tree Fruit Experiment Station at Wenatchee. Some of the necessary equipment, cabinets, sinks and tables for a soil laboratory are already available in the new quarters.

Blue Mountain Research Center

In November, we completed negotiations with Pilot Rock Lumber Company for a cooperative research project designed to study all aspects of lodgepole pine management in the Blue Mountain area. In accordance with the terms of the agreement the research program will begin in the Spring of 1956 with a study of multiple-use requirements of the lodgepole pine type. Our first step has been to outline the objectives of the first three-year period covered by the agreement. These were discussed with Pilot Rock Lumber Company in mid-March to reach agreement on our immediate goals as well as our long-term research program. During the coming summer season we plan to:

(1) Make a reconnaissance soil study of the lodgepole pine type.
(2) Study the characteristics of existing lodgepole pine stands.
(3) Examine available lodgepole pine cutover areas.

Preliminary investigations as well as the program to follow will be concerned with all of the characteristics which affect forest, watershed and range management. In the watershed management phases we intend to measure the effect of harvest and intermediate cuts on snow and soil moisture. Plots will be established to test the influence of various cutting systems on snow accumulation, rate of snow melt, storage of soil moisture and its seasonal depletion.

These same plots will provide information of interest in forest and range management research. It will be possible to measure flight of seed, distribution and survival of reproduction, influence of slash disposal methods, development of herbage and the impact of sheep grazing on density of reproduction.

We plan also to select two experimental drainages having a predominant cover of lodgepole pine. Combined timber and grazing treatment is contemplated for one of them after a sufficient period of calibration.

Treatments will be governed by the information developed in our plots.

In mid-June James Trappe will report to the Blue Mountain Research Center to handle the lodgepole pine project as well as other watershed research we are able to undertake. Trappe fills a new position made possible by the cooperative contribution from Pilot Rock Lumber Company and watershed management research funds.

Siskiyou-Cascade Research Center

It has not been feasible to begin watershed research in the Siskiyou-Cascade Research Center despite the growing importance of watershed problems in southwest Oregon. Public awareness of the relation of water resources to forest and rangeland use has been heightened by the floods of November and December. On the three national forests located in southwest Oregon, cost for repair and replacement of roads, trails and bridges is conservatively estimated at $300,000. Untold damage to property outside national forest boundaries is many times this figure and in addition there has been considerable loss of life.

During the past year a group of water-minded people in the Roseburg area have formed a working group known as the Douglas County Water Resources Board. An engineer has been hired to collect basic information and study the needs for water control in the Umpqua River basin. We have assisted in the job of accumulating precipitation data by loaning them a Q-12 recording rain and snow gage and have cooperated in a number of other ways.

Bull Run Project

In November of 1955 we completed arrangements with the City of Portland Water Bureau for a cooperative research project in the Bull Run watershed. The City is contributing sufficient funds to support a position for a full-time project leader. After considerable effort we have been able to fill this position with a competent watershed research technician. In the meantime, we have been able to make a substantial beginning by the use of temporary personnel. First job has been to collect and analyze available data on the Bull Run watershed and to summarize past activities which will affect development of our research program.

Miscellaneous

At the Society of American Forester's convention in Portland, Dunford presented a paper on watershed problems of the Pacific Northwest. He also described watershed management research activity to classes in watershed management at both Oregon State College and the University of Washington. Watershed management courses in the curriculum of these two schools is the "new look" in forestry education here.

Conditions are building up for another flood of 1948 proportions in the Columbia River basin. A record-breaking snowpack lies in the mountains, unaffected as yet by any real melt weather. In Oregon the April 1 cover is 130 percent of normal above 5,000 feet and 170 percent of normal for courses located below that elevation. The entire Columbia basin with the exception of the Snake River has 20 percent greater snow-water depths. Yakima, Willamette, and Wenatchee Rivers promise to be especially bad actors, having depths of 68 to 75 percent above normal. To make matters more critical the soil mantle is unusually well primed with moisture in the entire Columbia River basin. Only a dry spring and an exceptional run of cool nights can prevent damaging floods.

SEMIANNUAL REPORT -- OCTOBER 1955 THROUGH MARCH 1956
Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

Fraser Hydrologic Laboratory

Does intercepted snow evaporate?

Many studies have shown an inverse relationship between forest density and snow accumulation on the ground. In the literature, the universal explanation is that interception of snow by the forest canopy results in greater evaporation loss than occurs if the snow falls directly to the ground or snow pack surface.

Occasionally, however, questions have been raised as to the validity of conclusions that cutting timber actually increases the snow pack. It is argued that clearings, whether natural or created, simply cause a different distribution of snow; that the greater amount of snow found in clearings is there at the expense of snow in the surrounding forest. In support of this argument is the fact that to account for the apparent interception loss, the rate of evaporation from snow on tree crowns must be very much greater than any measured rate of evaporation loss from the snow pack. For example, Wilm and Dunford in USDA Technical Bulletin No. 968 attribute an average annual loss of 2 inches of water to evaporation from the snow pack on clear-cut plots. The corresponding loss from uncut forest attributable to interception and subsequent evaporation is about 5 inches or 2.5 times as much.

The explanation that snow on trees is more exposed to the weather and presents more surface than if in the snow pack, is interesting but unconvincing in the absence of corroborative data and analyses.

If we assume the validity of Sverdrup's equation for evaporation as given by Light (AGU Trans. 1941, Part 1, p. 195) or Diamond (Snow, Ice, Permafrost Research Establishment Research Paper 6, Nov. 1953), then a rather superficial but perhaps worthwhile test can be made as to the reasonableness of an evaporation rate from intercepted snow 2 or 3 times that from snow on the snow pack surface.

As given by Diamond, Sverdrup's equation is:

$$F = \frac{0.623\ R\ K_o^2 U_a (e - e_s)}{\ln \frac{a}{Z_o}\ \ln \frac{b}{Z_o}\ P}$$

where F = evaporation rate, R = density of air, K_o = Von Karman's constant, U_a = wind velocity at height a, e = vapor pressure of air above snow surface, e_s = vapor pressure of snow at 0° C., P = atmospheric pressure, a = height of temperature and humidity instrument above snow surface (assumed by Diamond to be 2 meters), b = height of anemometer (assumed to be 6 meters), Z_o = roughness parameter for snow pack surface = 0.25 cm.

Certain of the above factors are constants over the range in elevation from snow pack surface to forest canopy surface. These are:

coefficient 0.623, R, P, K_o, e. The factor e should also be essentially a constant because of the effect of snow at both elevations. a and b are also constants if we consider measuring temperature, humidity, and wind above the forest canopy to get data comparable to such data collected with reference to the snow pack. In one case a and b would be measured with respect to the snow pack, in the other with reference to the surface of the canopy.

If we set up two equations for F having the ratio 2/5 between their values and recognize the constants assumed above, then:

$$2/5 = \frac{\frac{U_1}{\ln\frac{a}{Zo_1}\ln\frac{b}{Zo_1}}}{\frac{U_2}{\ln\frac{a}{Zo_2}\ln\frac{b}{Zo_2}}} = \frac{U_1}{U_2}\,\frac{\ln\frac{a}{Zo_2}\ln\frac{b}{Zo_2}}{\ln\frac{a}{Zo_1}\ln\frac{b}{Zo_1}}$$

where subscript 1 refers to open area, snow pack variables and subscript 2 refers to variables at the forest canopy.

This equation can be satisfied if $\frac{U_1}{U_2} = 0.4$ and the remaining term = 1 or if the reverse is true. The first case sets the condition that $Zo_1 = Zo_2$ and $U_2 = 2.5U_1$ or wind over canopy is 2.5 times wind over snow pack.

If we set $\frac{U_1}{U_2} = 1$ and put in values for a, b, and Zo_1 in centimeters:

$$0.4 = \frac{\ln\frac{600}{Zo_2}\ln\frac{200}{Zo_2}}{\ln\frac{600}{0.25}\ln\frac{200}{0.25}}$$

$$0 = (\ln Zo_2)^2 - 11.7\ln Zo_2 + 13.0$$

By quadratic equation we get $\ln Zo_2 = 1.2$, $Zo_2 = 3.4$ cm.

Whether a value of 3.4 cm. for the roughness parameter of a snow-covered forest canopy is reasonable or not is not known. It seems certain, however that it would be materially greater than 0.25 cm.

A wind speed over a forest canopy equal to 2.5 times that over an open snow pack, while perhaps high, is probably not unreasonable. Data collected at Fraser over a period of 1 month by anemometers in an opening about 200 yards in diameter showed windflow at a height of 100 feet to be about 1.5 times that at 6 feet.

If we use $\frac{U_1}{U_2} = \frac{1}{1.5}$ in above equation and solve for Zo_2, we get $Zo_2 = 1.2$. Perhaps some of you readers who spend much time in trees either from force of work or heredity can tell me whether this value for Zo is too high.

All of this analysis ignores the greater surface exposed by snow on trees. It also ignores the possibility that much evaporation occurs when snow that has been intercepted is subsequently blown away in smokelike clouds-- a common phenomenon in the Colorado Rockies at least.

Although you readers may not share his emotions, the author currently feels even slightly more confident than previously in existing conclusions as to the effect of timber cutting on snow accumulation. He will be even happier, however, when they have been tested by rigorous studies designed for the purpose.

What melts snow in Colorado Rockies?

The planning of new snow studies has led to some preliminary thinking on what causes snowmelt in the Colorado Rockies of which the Fraser Experimental Forest is representative in many respects.

A review of the literature on the thermodynamics of snowmelt would lead one to the conclusion that the necessary heat comes mainly from the air by convection and from air-borne water vapor by condensation. The direct effect of solar radiation is given little credit.

The actual observance of snow melting in this part of the world would lead one to conclude that direct solar radiation is highly important. At lower elevations, south slopes are bare during much of the winter while north slopes stay snow covered. In spring, at higher elevations, south slopes become bare before melting even starts on north slopes.

The heat supplied by convection and condensation is primarily a function of wind, air temperature, and dew point. A quick look at values of these variables as they occur on the Fraser Forest during a sample period sheds light on the difference between conclusions expressed in the literature and those gained from field observation.

During 2 weeks in May on the Fraser Forest, wind averaged 4 miles per hour, air temperature 41° F., dew point 29° F. Only 30 percent of the time was the dew point above 32° F. and the maximum for the period was 41° F.

A very rough but indicative comparison among convection, condensation, and radiation as heat sources can be made by simply using these average values in charts given by W. T. Wilson in AGU Transactions 1941, Part I, page 187. By doing so, we conclude that heat from convection during the period could have melted snow at the rate of about 0.16 inch per day. Using the average dew point of 29° F., we, of course, come out with no heat gain at all from condensation.

An approximation to snowmelt by solar radiation we can get by referring to charts presented by Gerdel, Diamond, and Walsh in Snow, Ice, Permafrost Research Establishment Research Paper 8, 1954. Using May 20 as a sample day, a sky condition of 5/10 clear and a conservatively high albedo of 70 percent we get an estimate for snowmelt of 0.5 inch per day. This value is for a level area at 9,000 foot altitude.

A less sketchy analysis that used short period averages for temperatures and dew points would certainly result in different magnitudes for the snowmelt by heat from different sources. However, there seems little reason to doubt our senses when we see wet snow or bare ground on a south aspect and feel dry snow around our chins on a north slope. (B. C. Goodell)

Manitou Experimental Forest

When compared with nonuse, each of the three grazing intensities significantly reduced infiltration

Only the pine grass and grassland cover types are affected by cattle grazing. Little grazing use is made of the pine-litter type because of the lack of a forage understory. Studies made in 1947 and 1954 of the former 2 types inside and outside exclosures established in 1940 provided information on the effects of the 3 grazing intensities as employed in the 6 experimental range units.

The data from 12 exclosures for both the years and for both the grazed cover types were combined to form the basis of analysis. The analysis showed that without question any type of grazing, whether light or heavy, resulted in a reduction in infiltration when compared to nonuse. The results of the study are illustrated in figure 1.

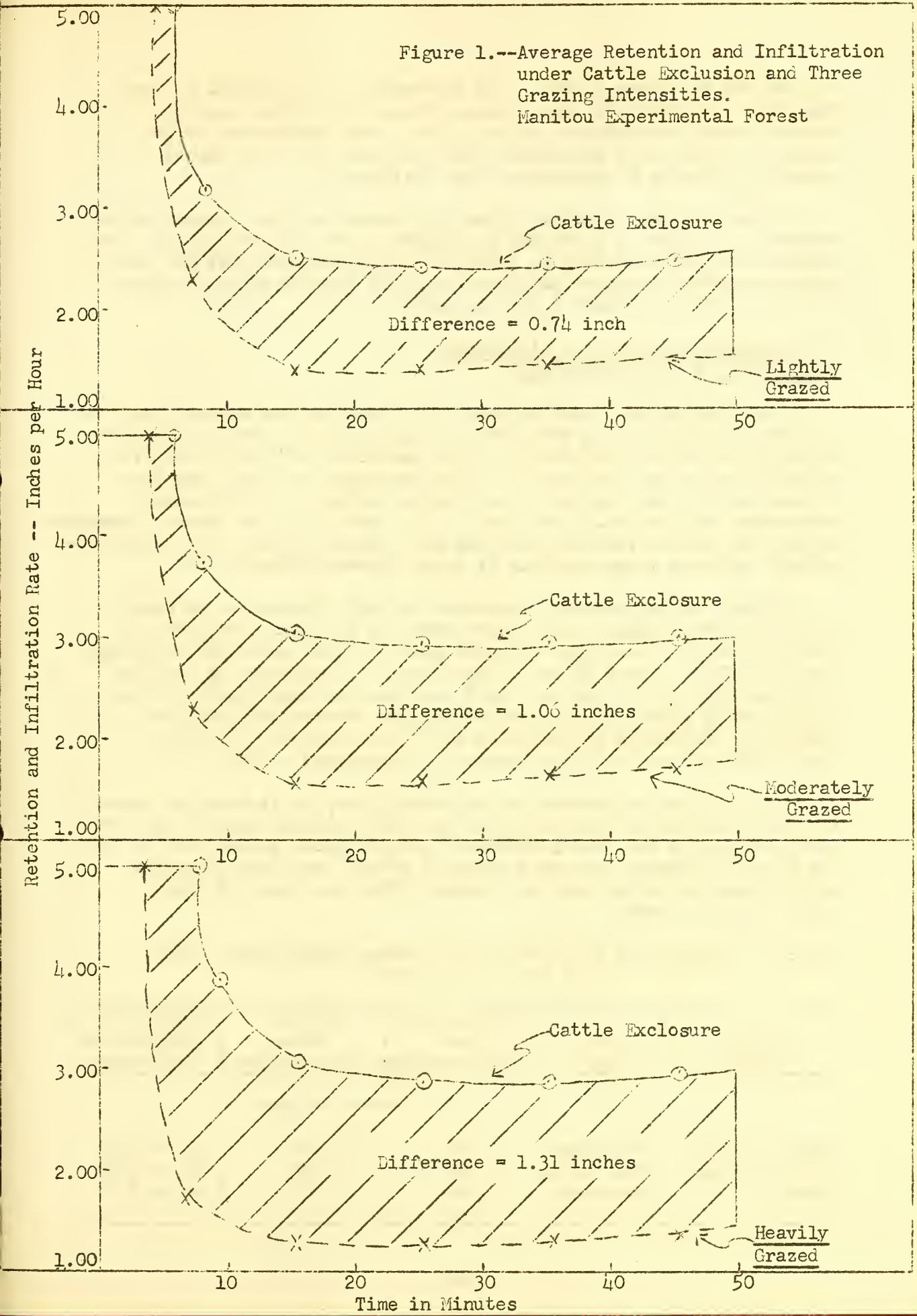
The differences reported are based on the average retention and infiltration rates for the 50-minute "wet run" for the plots inside the exclosures minus the values for the plots outside. The exclosures representing each of the 3 grazing intensities form the basis for the comparisons. Values for all inside plots could not be combined because of the inherent differences between the exclosures. Thus the measurements inside the exclosures of the lightly grazed units were compared with those outside, similarly, comparisons were made for plots moderately and heavily grazed. In this manner the effects on infiltration of the 3 different intensities of grazing were demonstrated.

Cattle grazing reduces litter accumulation and compacts the surface soil

Cattle grazing reduces litter accumulation on the soil surface by removing annually portions of herbaceous material which otherwise would become litter if left untouched. Through trampling, the large pores in the surface soil, which facilitate the downward movement of water, are compressed into smaller pores which inhibit the downward movement of water. The amount of litter on the soil surface and the amount of large pores in the surface soil strongly govern infiltration rates. Both may be altered by cattle grazing.

Studies made in 1954 of the 12 exclosures in the 6 range units at the Manitou Experimental Forest illustrate the effects of cattle grazing on the above two factors. Comparisons were made of the rate at which water moved through surface 2-inch soil cores taken from plots inside and outside the exclosures. It was found that water moved more slowly through the soil cores of the grazed plots than

Figure 1.--Average Retention and Infiltration under Cattle Exclusion and Three Grazing Intensities. Manitou Experimental Forest



through the exclosure plots. This difference is attributed to the difference in amount of large pores. Since the surface soil was similar inside and outside the exclosures, this difference in the amount of large pores was considered to be the result of cattle trampling. Figure 2 illustrates this difference.

Figure 2 also illustrates the difference in litter accumulation between all exclosure plots and all grazed plots studied in 1954. The measurements are expressed in grams per 2½-square-foot plot and the difference when converted to pounds per acre amounts to 2,160 pounds, enough to materially affect infiltration.

Infiltration is related to litter and large pores of the surface soil

The minimum infiltration rate (fc), based on the average rate for the last 20 minutes of a 50-minute run, is commonly used to relate to factors influencing infiltration. The magnitude of this minimum rate is reflected in the infiltration curve for each plot "run" and thus becomes an index of the particular factors affecting infiltration associated with an individual plot "run". This relation makes it possible to use the minimum infiltration rate (fc) for each plot "run" as the dependent variable in an analysis of those factors affecting it.

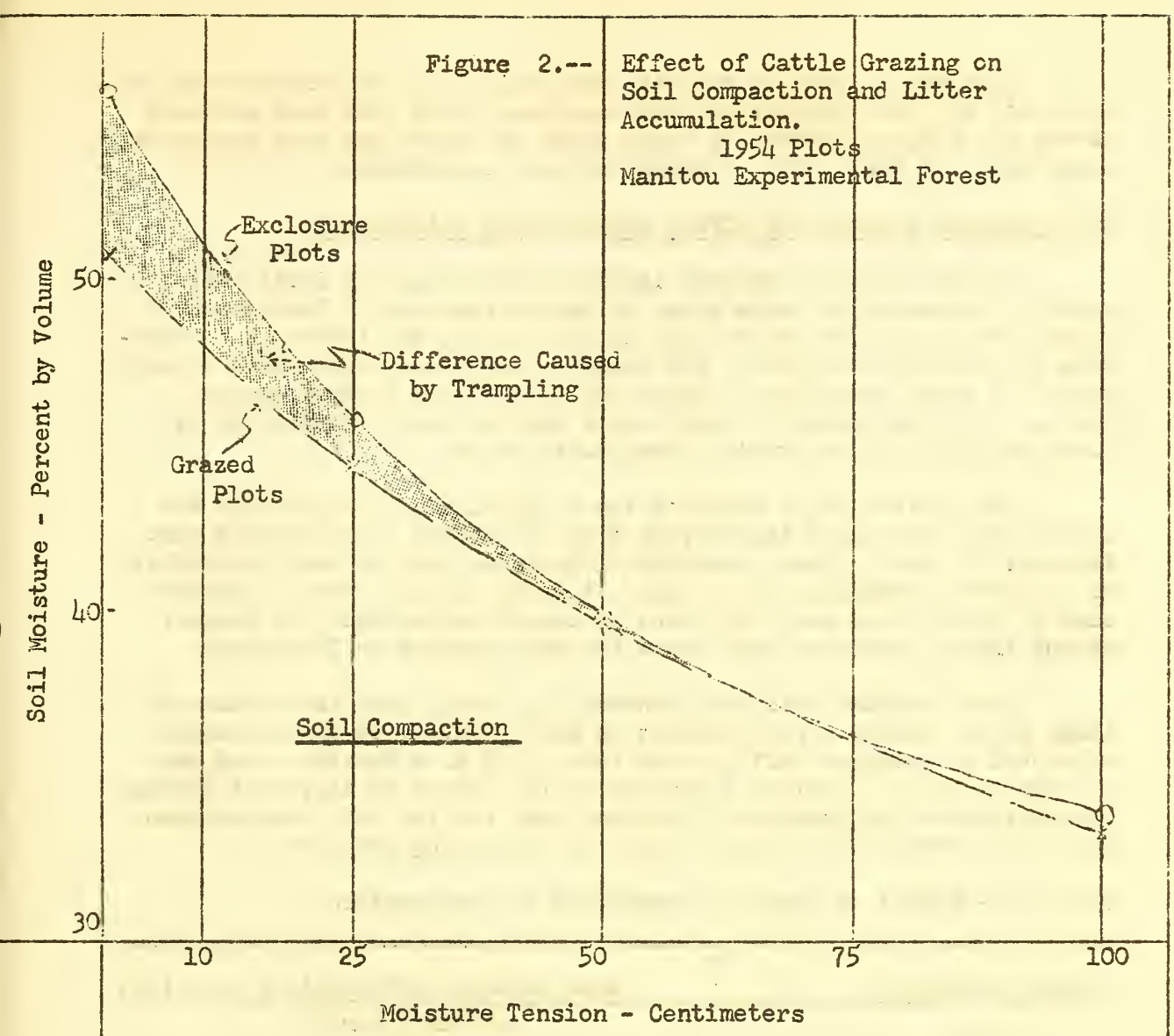
After testing several vegetation and soil factors which might be related to the minimum infiltration rate, it was found that only 2, namely, grams of litter per plot and percent large pores in the surface 2 inches of soil, were of major importance. An analysis of the 1947, 1952, and 1954 plot "runs" on the 6 experimental range units provided the following expression for estimating the minimum infiltration rate (fc): ESTIMATED INFILTRATION (fc) - Inches/hour = 0.00288 (grams litter/plot) + 0.0374 (percent large pores) + 0.43.

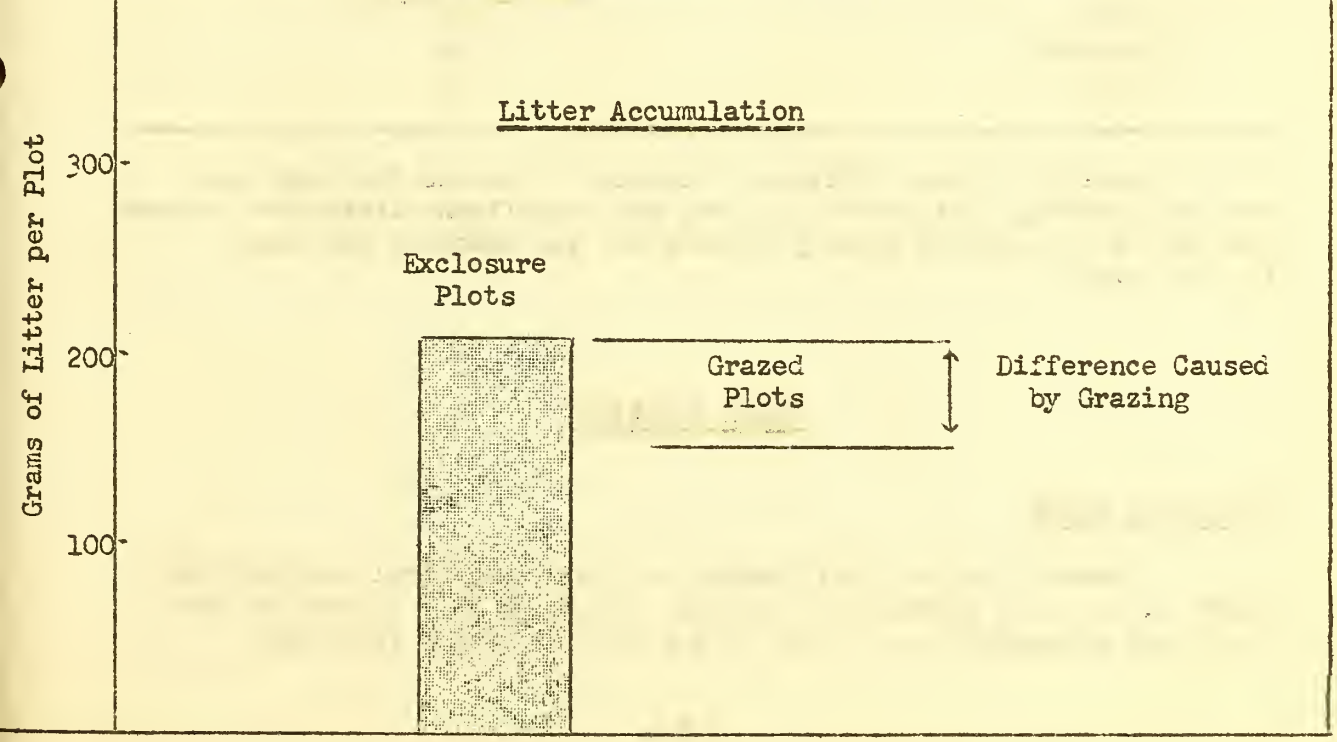
For such an expression to be generally useful it must be tested in other localities. One such test was made by comparing the infiltration measured by the "Rocky Mountain" infiltrometer during 1950 on the Elk Ridge Allotment, Roosevelt National Forest, with the estimated values based on litter and large pores. The table which follows summarizes this test.

Table 1.-- Comparison of actual and estimated infiltration rates, Elk Ridge Allotment

Soil origin	Cover type	Estimated mean infiltration	Actual mean infiltration	Range of infiltration on plots
		- - - - Inches per hour - - - - -		
Granite-schist	Grassland	1.50	1.81	1.27 to 2.25
Granite-schist	Pine-grass	2.18	2.14	1.31 to 2.97
Schist	Grassland	1.52	1.63	1.12 to 2.14

Figure 2.-- Effect of Cattle Grazing on Soil Compaction and Litter Accumulation.
1954 Plots
Manitou Experimental Forest





Apparently, equally accurate measurements of the minimum infiltration rate for each vegetation-soil condition could have been obtained on the Elk Ridge Allotment by using grams of litter per plot and percent large pores in the surface 2 inches of soil exclusively.

The 3 grazing intensities affect infiltration differently

One of the major factors influencing the minimum infiltration rate is the amount of large pores in the surface soil. The amount of large pores in a surface soil are dependent upon the texture and structure of the soil materials. For example, sandy soils will have a large amount of large pores while clayey soils will have a small amount (unless well aggregated). Sandy soils tend to resist compaction by trampling by livestock while clayey soils do not.

The surface soils found on the 6 experimental range units are sandy loams varying on the average from 59 percent to 70 percent sand from unit to unit. These inherent differences tend to mask the effect of livestock trampling; for example, a heavy-use unit with 70 percent sand in the surface soil will tend to resist compaction to a greater extent than a light-use unit where the sand content is 59 percent.

Since surface soil sand content, by controlling the amount of large pores, exerts a major effect on infiltration, it was necessary to adjust all minimum infiltration rates (fc) to a constant sand percentage in order to obtain a measure of the effect of different grazing intensities on infiltration. This was done for the 1952 observations, when sand content was obtained, with the following results:

Table 2.-- Effect of grazing intensities on infiltration

Grazing intensity	Mean adjusted infiltration rate (fc)
	Inches per hour
Light	1.86
Moderate	1.94
Heavy	1.52

There is no real difference between the values for light and moderate grazing, but there is a real and significant difference between the values for light and heavy grazing and for moderate and heavy. (L. D. Love)

Grand Junction

Oak brush study

A manuscript entitled "Gambel oak in west-central Colorado" by Harry E. Brown is nearing completion. Following is a summary of the study and a description of some of the more important findings:

The oak brush type in west-central Colorado was investigated in 1953 and 1954 to learn some of the characteristics of oak brush and its environment; to find out whether oak brush is spreading or has spread in recent years; and to evaluate the type for various purposes.

Oak brush comprises a major part of the vegetation between 7,000 and 9,000 feet in the study area. On gentle slopes it usually grows in clumps, while on the steeper slopes it more commonly occurs in thickets.

About half the oaks in a normal stand are less than ten years old. The remainder are distributed rather uniformly throughout the 10 to 80-year-old age classes. Trees older than 80 years are relatively scarce, indicating a natural early mortality. The average mature tree is about 13 feet high and 3 inches in diameter.

Oak stands are most dense when young, especially following a fire or other disturbance which stimulates sprouting. As the stands mature they become thinner.

Very few of the oak stands observed in 1953 and 1954 appeared to be spreading, as evidenced by the scarcity of sprouts in the openings between stands. Although some stands have thickened in recent years, usually as a result of fire, others have become thinner. Consequently, the general extent and nature of the type is probably not greatly different today than it was in the late 1800's.

Total production of grass and sedge was similar under oak and in the openings, averaging 346 pounds per acre. Elk sedge and Kentucky bluegrass were dominant under oak and in the openings, respectively. Forage production on most sites is considered to be less than half the potential.

Utilization averaged 24 percent on all sites. It was not consistently higher in the openings than under oak, indicating that many oak stands are not as inaccessible to livestock as they are commonly thought to be.

Although characteristics of the surface soil were quite variable, soil factors do not appear to limit the distribution of oak brush. Average depth of the surface soil on all sites was 18 inches. Under oak, soil depth was fairly uniform regardless of slope, whereas in openings the soil averaged eight inches shallower on steep slopes than on gentle slopes. Soil stability was rated as "excellent" under oak and "fair" in the openings.

The average ground cover index under oak was 95 percent compared to 68 percent in the openings.

In evaluating oak brush lands for grazing, watershed, and game uses, individual sites should be appraised rather than general areas. Consideration should be given to the important function of oak brush in preventing erosion and flashy runoff from watershed lands. Its removal from steep slopes with shallow soil might result in serious damage to the watershed. However, dense thickets on gentle slopes

with deep soil could probably be converted safely to a herbaceous cover. This would tend to relieve the critical shortage of spring-fall range for livestock and would permit more uniform grazing use of the range.

The value of oak brush as forage and cover for big game is important chiefly on certain winter range areas where other browse plants are not available.

Further studies are needed to determine more specifically the conditions under which control or conversion of oak brush should be attempted.

Black Mesa watershed studies

One weir has been completed on Black Mesa to gage snowmelt runoff and sediment production from a 200-acre watershed. The watershed is a part of the Black Mesa experimental ranges and lies at about 9,000 feet in the mountain-grass, aspen, spruce-fir types. Although complete measurements are expected only from this one gage in 1956, two other gages are scheduled for completion this year. Comparison will then be made to determine the effect of grazing treatments on watershed values.

Rapid City

A new unit has been established at Rapid City, South Dakota, to carry on research in the forest land problems of the Black Hills. Howard K. Orr is transferring from the Intermountain Station in April to lead watershed research. His first task will be to study available precipitation and streamflow records and prepare a report on the trend of water yield. There is a widespread belief that the proportion of precipitation contributing to streamflow has been steadily decreasing in the Black Hills. Although no change has been definitely shown, there are a variety of beliefs as to why it has occurred. Decrease in yield has been attributed by some to the increase in the density of pine stands and by others to the death of streamside willows.

The Black Hills National Forest has been carrying on a program of thinning to improve timber growth. The effect of this practice on water yield and soil moisture is unknown. During the summer, plots will be established and precipitation and soil moisture sampled to compare unthinned and thinned ponderosa pine stands with clear-cut areas. Another project to be initiated is the effect of intensity of grazing and season of use upon soil structure. The first step in this will be to determine the amount of recovery during the winter nonuse period. Pore space and permeability measured on soil cores will be used to compare treatments.

Albuquerque

Palpant just returned from Fort Collins where he completed some graduate studies during the winter quarter at Colorado A. & M. He appears worn and thin (Analytics plus Statistics) but raring to go on new research. The other watershed half, Dort, also returned from Fort Collins, where, with Dud Love, results of over 1,000 infiltrometer tests have been brought together for publication. Rio Grande research efforts have thus been stymied, recently.

During 1957, some watershed management studies or phases will be closed out, others strengthened, and some new ones started.

Pine Flat study area

Considerable interest in pinyon and juniper eradication is developing in New Mexico as a result of highly successful eradication work in Arizona. Substantial increases in forage production attributed to removal of competing trees have been demonstrated. The uppermost question now, is--what is the overall effect of tree removal on water production or yield?

The old Pine Flat soil moisture study started by VIP in 1953 will be terminated and results are scheduled for presentation at the national American Meteorological Association meeting to be held in Albuquerque this fall. A continuing study at Pine Flat includes the relation of infiltration, as measured with the rainfall simulator, to soil moisture. Some results appear in the Station's 1955 Annual Report but that is only a brief glimpse of the findings. A detailed report will be given in the next issue after this spring's tests are completed on the same plots to evaluate over-winter effects of freezing and thawing. Plans for installing surface runoff plots are being formulated. These plots are needed for a better indication or overall appraisal of the effect of pinyon and juniper removal and replacement with grass.

Reseeding in New Mexico

The effect of reseeding northcentral New Mexico rangelands is being summarized in a report proposed for publication. Additional field studies at 2 sites will be continued during the next 5 years. Infiltration and associated soil tests were started on these sites before the sagebrush was plowed and continued at intermittent periods since then. Some of the plots will be grazed and others will be protected from grazing to provide a better measure of the cattle trampling effect on soil and infiltration.

San Luis watersheds (Rio Puerco)

Water and sediment production from three contiguous deteriorated range watersheds is being evaluated. Watersheds are representative of plant-soil-water conditions in the Rio Puerco which contritubes

almost half of the sediment but less than 8 percent of the water to the Rio Grande valley. Watersheds which total 1,700 acres are eroding at a severe rate. The Bureau of Land Management and U. S. Geological Survey, cooperators in this investigation, plan to strengthen their participation in 1956. Fencing of individual watersheds (a B.L.M. contribution) is about half completed.

An attempt will be made to measure sediment inflow into each reservoir on a weight as well as a volume basis to account for compaction of sediment deposits with time. Weirs will be installed on spillways of each catchment basin for permanent control and better measurement of overflow during rainstorms. Installation of surface runoff plots is planned to supplement watershed measurements.

Forage capacitance meter

Infiltration and erosion rates are related to the amount of crested wheatgrass or native herbage present on sites in New Mexico. Litter quantity also provides a good index. A simple rapid method for determining weight or mass of live and dead organic materials is not only needed in research and management pertaining to range but also in regard to watersheds. Some measure of watershed conditions might thus be easily incorporated into the 3-step method.

The capacitance meter developed by Joel Fletcher and Max E. Robinson, reported in the March 1956 issue of the Journal of Range Management, offers a good possibility for obtaining more complete sampling of vegetation because of the rapidity of the method. This instrument should prove useful in range watershed research investigations as well as in management.

Palpant constructed a modified capacitance meter in 1955 and plans to test it under field conditions this coming summer.

Small watershed program

The Research Center is cooperating to a limited extent with National Forest Resource Management on the Department's small watershed program. We installed rain gages on the land-treated Bernalillo watershed in 1954 and have assisted in taking and compiling records. Our small contribution was minor, but it indicates the importance of being there at the right time. This is perhaps more important in watershed management than in any other field.

In July 1955, a series of intense rainstorms occurred on the Bernalillo watershed. This same storm caused more than $1 million flood damage in the Albuquerque flood plain about 15 miles south of the Bernalillo watershed. Yet, surface runoff failed to reach the partially constructed Soil Conservation Service dam on the Bernalillo watershed, indicating the full effectiveness of land treated with terraces, pitting, chiseling, and other measures on 1,300 acres of national forest land.

A complete report with photographs is available for in-service use. It is entitled, "The Bernalillo 'Land Treated Watershed in Action'", by E. J. Dortignac and Ranger Harlan Johnson.
(E. J. Dortignac)

New watershed management recruit at Sierra Ancha

Howard L. Gary reported for duty November 7, 1955. He was assigned to general watershed duties on the experimental forest under the supervision of Lowell Rich. He is a graduate of Texas A. & M. and has served a 2-year hitch with the Army.

Brushland conference

Considerable interest has developed in central Arizona concerning the possibility of obtaining increased water yields by removing brush from Arizona watersheds. On February 10, a brushland conference was held in Phoenix, Arizona, in which interested federal and state agency representatives and private interests expressed their needs, experiences, and desires with regard to brush control. As a result of this meeting, an executive committee was formed and Roger Ernst, State Land Commissioner, is to act as chairman.

Salt River watershed evaluation

Dr. George W. Barr of the University of Arizona is undertaking an economic investigation of the possibilities of increasing water supply by watershed modification on the Salt River Drainage Basin. Various experts in federal, state, and private employment will be consulted and available research information evaluated. The main objective of the analysis is to recommend the economic feasibility of watershed treatment for water yield based upon present knowledge. The unit has been consulted several times by Dr. Barr and his associates.

Phreatophyte program

An outline of a problem analysis concerning phreatophytes in the Southwest has been developed. Six research approaches to the problem are recognized. The biological control approach anticipates testing of chemicals and possibly organisms for eradicating undesirable phreatophytes. Ecological manipulation foresees studying life histories of the more important species in order to determine the weak link in their development and the possibility of influencing species composition. Physiological investigations will be concerned with a search for more efficient species of phreatophytes through transpirational and root absorption studies. There is also the possibility that atmospheric and solar conditions surrounding phreatophytes can be modified by natural and artificial barriers. Finally, ground water relations may be modified by such techniques as piping, channeling, or otherwise diverting flowing water around or through dense stands of phreatophytic growth.

A brief of this analysis together with the known facts concerning phreatophytes in the Southwest is being prepared for release as a Station mimeographed report.

Three-Bar experimental watersheds

Plans have now been formulated for construction of four weirs and gaging stations. Calibration will probably begin during the summer rains. An area adjacent to the experimental watersheds was burned last spring. Vegetative changes, forage and browse production, and utilization by deer are being followed in cooperation with the Arizona Game and Fish Commission. In addition, this latter organization is collecting samples of browse species on burned and adjacent unburned areas for analysis of protein and phosphorus.

Castle Creek watersheds

This experimental area, located near Beaverhead, Arizona, was selected to study the effect on water and sediment yields of national forest timber cutting in mature ponderosa pine. Weirs were completed December 1, 1955, and water level recorders were installed March 1, 1956. Snow in the weir basins and observations of the channels above and below the weirs indicated no runoff between December 1, 1955, and March 1, 1956. Warm weather between March 1 and 15 started snow melting. On March 5, water started flowing over the West Fork weir and on March 11, over the East Fork weir.

A Weather Bureau observer, Norman Josh, has been hired to keep records on the watersheds.

Workman Creek timber harvest

Timber cutting on the South Fork of Workman Creek was completed in November 1955. Storms stopped the logging operations, and an estimated 50,000 board feet of logs remain in the woods.

Based on sample plots, the trees marked for cutting comprised 24 percent of the basal area of the trees on the watershed. The following priorities have been set for the post logging treatment to bring the total basal area reduction to the desired 35 percent:

(1) Remove the dwarfmistletoe infected ponderosa pine
(2) Kill all hardwoods on the ponderosa pine sites
(3) If additional basal area reduction is needed to meet the desired level, hardwoods will be killed to favor ponderosa pine in the pine-fir and fir types

Infrared gas analyzer

This instrument, which will be used for transpirational studies of phreatophytes, was received in January. Difficulty

is being encountered in devising a reliable calibration system. A proposed injection-evaporation method proved unreliable. A vapor dilution method revealed unexplained anomalies suggesting the presence of an unstable surface film far in excess of that predicted in the literature. A gravimetric system has been set up and preliminary tests show a high degree of reproducibility. In this system the meter is calibrated against the actual loss in weight of an unstoppered weighing bottle of water. Although this may not necessarily give a reliable calibration in terms of vapor concentration (humidity), it does give a firm and direct calibration in terms of the dimension of most interest--loss in weight of an object in the system due to evaporation.

Phreatophyte subcommittee meeting

Informal discussion with several members (Blaney, Robinson, and Elmendorf) suggested the desirability of setting up somewhere a permanent Phreatophyte and Evapotranspiration Library. Negotiations have been made with the head librarian at Arizona State College for such a proposed depository. The next step will be a proposal to the subcommittee that A.S.C. be designated its official library.

Foliage relations of ponderosa pine

The following equations for estimating foliage characteristics of all-aged virgin stands of ponderosa pine have been developed at the Sierra Ancha Experimental Forest.

Log of foliage surface area (sq. m.) = (1.80094)(log of tree diameter inches) + 0.13835

Log of foliage weight (kg.) = (1.881122)(log of tree diameter inches) - 0.888166

Fascicle area (sq. cm.) = 5.645 + (54.502)(fascicle weight grams)

Mean weight per fascicle (gms.) = (0.005144)(tree diameter inches) + 0.111086

Chaparral shrub poisoning

Results of a plot study recently completed at the Sierra Ancha Experimental Forest and now in manuscript form indicate that more effective poisons are needed before large-scale control of sprouting chaparral shrubs will be possible in the Southwest.

Stem counts at the end of the second growing season following treatment showed that: (1) Effectiveness of the treatments did not vary between diabase and quartzite soils, (2) relatively poor complete plant kill was obtained even with the most effective treatment, (3) basal spray, on the average, was superior to the painted-stub

treatment, and (4) ammate basal spray applied during the dormant season was the most effective treatment (46 percent reduction in numbers of live stems), but failed to control the larger, more resistant stems. The D-T mixture was relatively more effective on these large stems. (5) The tabulation following shows the different reaction of the several species of chaparral to the treatments:

Poison	Method	Shrub oak	Buck-brush	Buck-thorn	Lemon-bush
		Percent of Original Number			
Brushkiller	Basal spray	70	6	50	49
Brushkiller	Painted-stub	116	2	367	55
Ammate	Basal spray	63	21	113	124
Ammate	Painted-stub	255	7	652	178
Control	Stems cut	159	13	615	207

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Fletcher, H. C., and Elmendorf, H. B. Phreatophytes--a serious problem in the West. U. S. Dept. Agr. Yearbook 1955: 423-429. 1955.

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Love, L. D. The effect on streamflow of the killing of spruce and pine by the Engelmann spruce beetle. Trans. Amer. Geophys. Union 36 (1): 113-118. February 1955.

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Manuscripts in Progress

Outside Publications

Brown, H. E. Oak brush in western Colorado.

Cable, D. R. Foliage area of ponderosa pine.

Cooperative Snow Investigations: Bureau of Reclamation-Forest Service. Final report of studies at Fraser Experimental Forest.

Fletcher, H. C. Water use by chaparral and semidesert vegetation.

Goodell, B. C. Snow research at the Fraser Experimental Forest.

Palpant, E. H., and Dortignac, E. J. Infiltration and erosion as influenced by range reseeding.

Rich, L. R. Water and sediment yields from natural drainage watersheds.

Processed Releases

Brown, H. E., and Dunford, E. G. Streamflow in relation to extent of snow cover.

Dortignac, E. J. Watershed resources and problems of the Upper Rio Grande Basin.

Orr, H. Water yields as related to climatic factors in the Black Hills of South Dakota.

Reynolds, H. G., and Decker, J. P. Phreatophytes in the Southwest.

Rich, L. R. Precipitation-streamflow relationships, Salt River, Arizona.

_____. Water and sediment yields from Summit watersheds.

Manuscripts Planned

Tempe

Decker, J. P. Use of infrared gas analyzer to measure water loss from plants.

Cable, D. R. Interception in old growth ponderosa pine.

Rich, L. R. Water yield characteristics of some Arizona watersheds.

Fort Collins

Love, L. D., and Berndt, H. W. Precipitation-streamflow relationships for a Front Range watershed.

Love, L. D., and Goodell, B. C. Precipitation-streamflow relationships for a high mountain forested watershed.

Grand Junction

Brown, H. E. Comparison of soil moisture under spruce, aspen, oak brush, and mountain grassland.

Albuquerque

Dortignac, E. J., and Palpant, E. H. Comparative soil moisture conditions under pinyon trees and blue grama.

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
October-December, 1955
DIVISION OF WATERSHED MANAGEMENT RESEARCH

COWEETA HYDROLOGIC LABORATORY

General

During the past nine months operational activities have been centered chiefly around installing watershed treatments and reducing the backlog of long-time watershed experiments scheduled by the 1953 Program Conference. Since there has been some delay in recruiting qualified personnel those funds have provided an opportunity for substantial progress to be made within the past months in the installation of studies or preparing watersheds for the next treatment. A total of 6 watersheds having an aggregate area over 300 acres received the following treatments:

Watershed No. 3. The pastured portion of this 23 acre watershed that was sown to oats and lespedeza in 1954 was planted to yellow poplar and white pine. For this drainage area tree planting completes the scheduled rehabilitation work.

Watershed No. 17. The 38 acres where slashing of all vegetation was made in 1941 and natural regrowth has been cut each year, received the final cut this summer. During November and December the cut stems of woody plants were sprayed with silvicide. This cleared area is scheduled for planting to white pine in February 1956.

Watershed No. 1. A 40-acre watershed where all the cove deep-soil type vegetation was treated by girdling and silvicides in 1954 had sprout regrowth that required follow-up work with silvicides again this year.

Watershed No. 22. One-half of all the shrub and tree vegetation growing on this 85-acre watershed was deadened by cutting or girdling, and silvicides, in a study of stand variables affecting water yields.

Watershed No. 41. This 70-acre drainage will be managed for maximum economic returns under a timber management system simulating that on national forest lands; and Watershed No. 40, a 50-acre area will be managed for optimum yield of useable water plus some supplemental timber returns in a study of comparative water yields under two systems of management. For both watersheds the first improvement cut and (K-V) stand treatment measures were completed during December.

Effect of Cutting Forest Vegetation on Diurnal Fluctuation of the Water Table

Eight groundwater wells on the Coweeta area are equipped with water level recorders to obtain a continuous record of the free water table. As shown in Figure 1 the water table depletion curve exhibits a strong diurnal fluctuation during the growing season. This is most pronounced on Well No. 7 but occurs at the other locations. Generally the diurnal fluctuation follows the transpiration draft on groundwater by the forest vegetation. For example, recovery takes place during the evening and night hours when transpiration is negligible.

In order to study some of the characteristics of this relationship a special study was made on Well No. 7. Beginning in June of 1954 and at intervals thereafter, surrounding forest vegetation was cut down in concentric circles with increasing radii as shown below. The vegetation around the well was pitch pine with hemlock, red maple, and hickory further out. The basal area was approximately 134 sq. ft. per acre.

Schedule of cutting

Date	Radius of Circle
6/21/54	8'
6/28/54	12'
7/6/54	16'
7/14/54	20'
8/2/54	28'
8/13/54	36'
9/9/54	44'

The results of the treatment are shown in Figure 2. The ordinate scale is the rate of change of the water table in feet per hour on the depletion portion of the diurnal fluctuation. This value also includes a component due to gradual seasonal depletion of the water table by contributions to streamflow, see Figure 1. This component need not be separated as it would not be affected by the treatment and, in fact, is equally present in the well hydrograph after cutting. It amounts to about .001 ft./hr. with some minor variation during the growing season.

A comparison of the curves in Figure 2 before and after cutting shows clearly that cutting the vegetation around the well has substantially reduced diurnal fluctuation. Water table levels were comparable in the three years shown and did not affect the results. For example, the cutting reduced the average rate in July and August from 0.010 ft./hr. to .002 ft./hr.

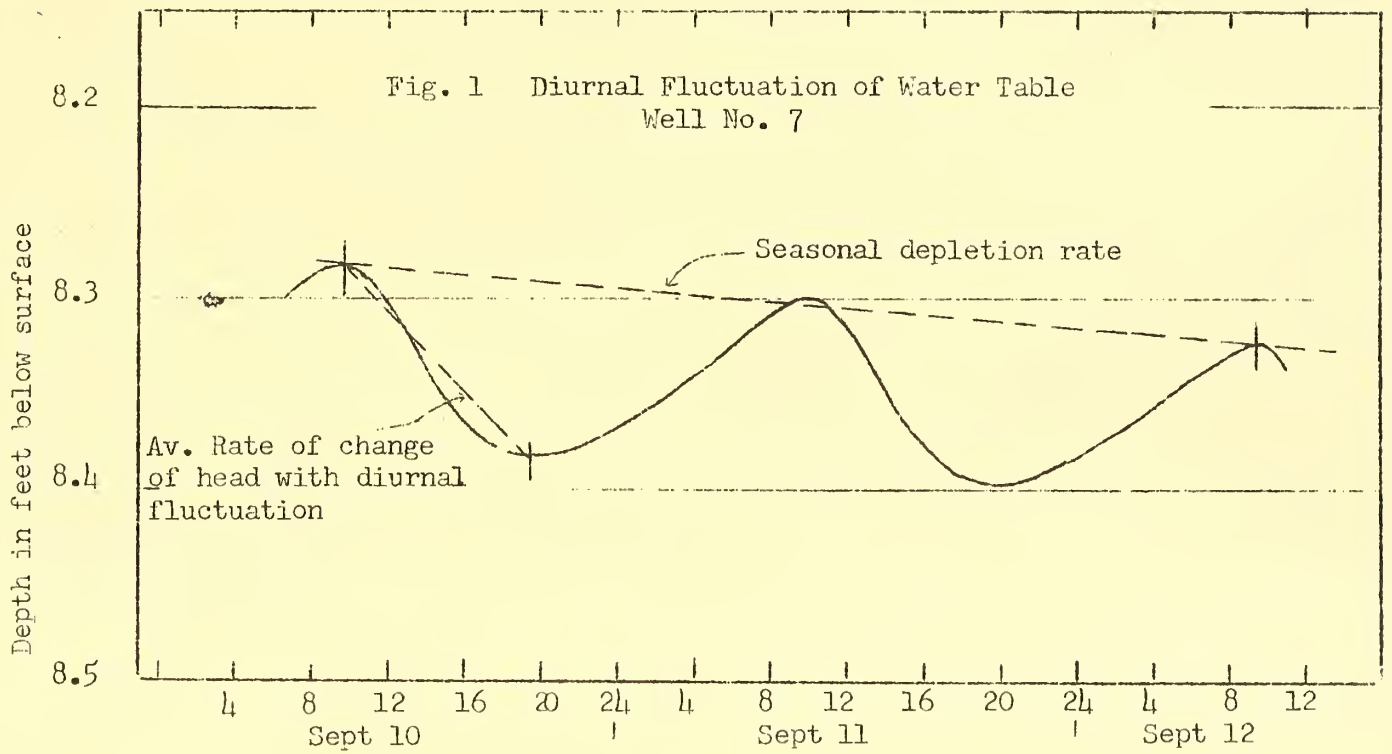
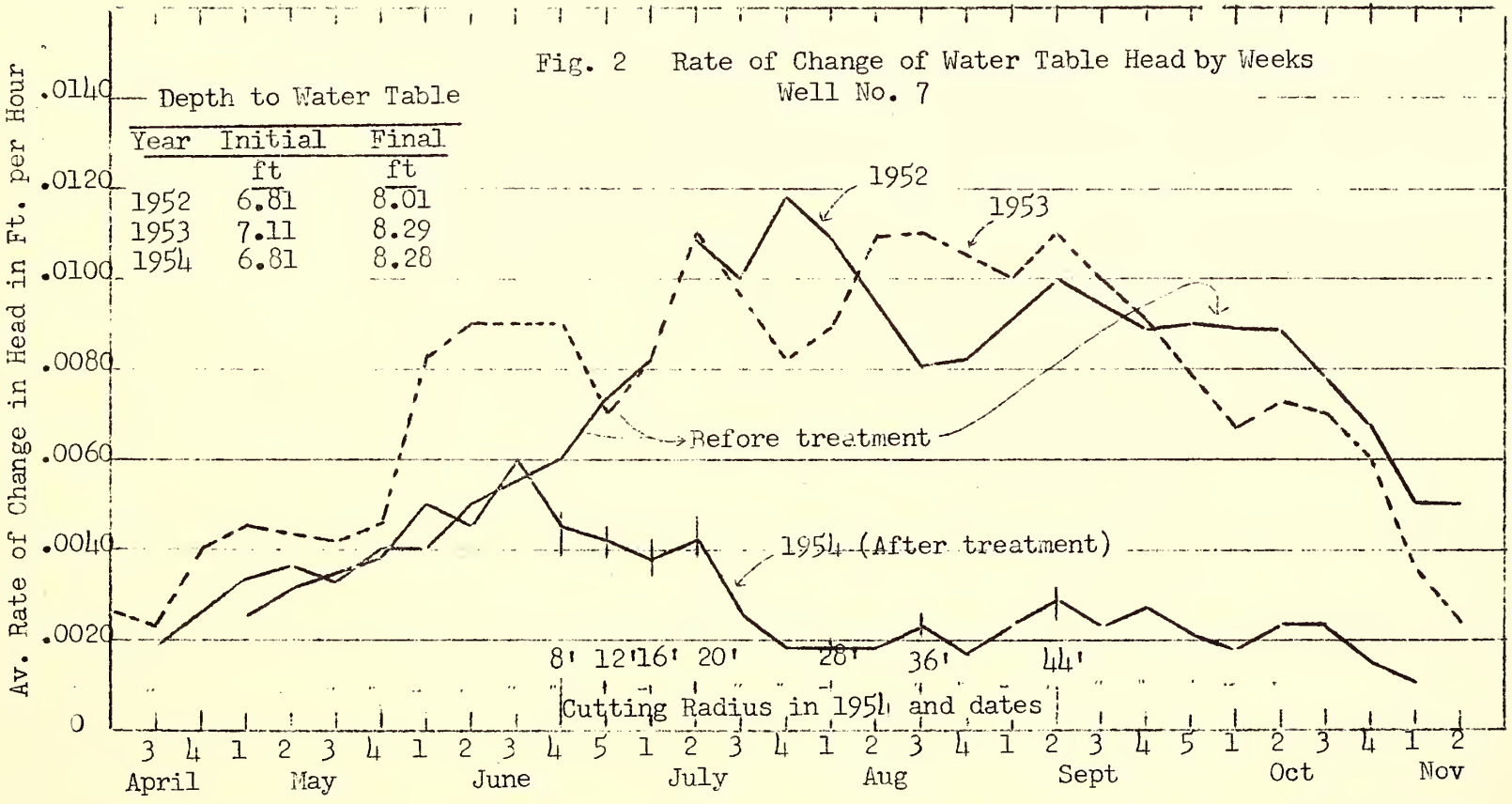


Fig. 1 Diurnal Fluctuation of Water Table
Well No. 7
Depth in feet below surface
8.2
8.3
8.4
8.5
Seasonal depletion rate
Av. Rate of change
of head with diurnal
fluctuation
4
8
12
16
20
24
4
8
12
16
20
24
4
8
12
Sept 10
Sept 11
Sept 12

Fig. 2 Rate of Change of Water Table Head by Weeks
Well No. 7


Depth to Water Table
Year Initial Final
ft ft
1952 6.81 8.01
1953 7.11 8.29
1954 6.81 8.28
1952
1953
Before treatment
1954 (After treatment)
Av. Rate of Change in Head in Ft. per Hour
.0140
.0120
.0100
.0080
.0060
.0040
.0020
0
8' 12' 16' 20' 28' 36' 44'
Cutting Radius in 1954 and dates
3 4 1 2 3 4 1 2 3 4 5 1 2 3 4 1 2 3 4 1 2 3 4 5 1 2 3 4 1 2
April May June July Aug Sept Oct Nov

The increase in the normal pretreatment curve was halted by the initial 8' cutting on 6/21/54. The 12' and 16' cuttings each appear to have had an additional marked influence, although the weekly intervals were evidently too short to bring out their full effect. The maximum effect was obtained after the 20' cutting with no additional decrease in the rate of change by the 28', 36', and 44' treatment. Further cutting would have little effect at this well since a rate of .002 ft/hr frequently occurs during the dormant season which may be attributed to diurnal variations in air temperatures affecting the recording apparatus.

The experiment confirms the results of other studies that transpiring vegetation in contact with the water table is responsible for the diurnal fluctuation. The treatment indicated, however, that vegetation growing outside a 20' circular area had little influence on the water table at the well. This was probably due to the slow lateral movement of water in the soil since diurnal fluctuation also occurred under those trees.

The water table ranged from 6.8' to 8.3' below the surface from April to November during the 1952-54 period. Allowing for capillary fringe, only those roots extending to a depth greater than 6 feet were effectively in contact with the water table. In addition the maximum temporary change in head amounted to only 1.5 inches. With the irregular distribution of free roots at the 6-8 ft. depth it cannot be assumed that the drop in the water table is everywhere uniform but must occur locally in the form of inverted cones or depressions.

Under these conditions, a tree 20 feet from the well would create localized depressions in the water table, which would not move water laterally through the soil from the vicinity of the well in the time alloted under a head of 1.5 inches. The nightly rise portion of the diurnal variation probably results from overall restoration of the free water surface.

Distribution of Storm Runoff from Watershed No. 3 Under Three Types of Land Use

The manner in which storm runoff comes off Watershed No. 3 depends on the land use. To show these effects average distribution graphs were computed from summer type thunderstorms having similar characteristics for the following period: 1934-1939, in a forest cover; 1940-1953, operating the watershed as a mountain farm; and 1954-1955, farm forestry restoration practices.

A definite change has taken place in the distribution of the storm runoff with each type of land use as shown in Figure 3. One notable effect is the change in time of concentration. While the watershed was in forest cover, the peak occurred approximately 35 minutes from the time storm runoff first began. When the area was operated as a mountain farm the peak occurred on the average of 15 minutes after storm runoff began, with some storms it was observed to be as little as 10 minutes. The first two years under a restoration program indicates that time of concentration has increased on the average by at least 6 to 9 minutes, or occurs 21 to 24 minutes after runoff begins. For a few storms late in the 1955 growing season a 27 minute concentration time was observed. Although there is an insufficient number of storms available now for a complete analysis, an inspection of the hydrographs suggests obtaining a family of distribution graphs that change with time under the restoration program.

It is apparent, too, that the peak percentage of storm runoff altered with watershed treatment. The maximum value for a forest cover was 12 percent, during mountain farming it increased to 32 percent, and under restoration changed to 16 percent. The 1954, 2nd Quarterly Report stated under mountain farming synchronization of stormflow had changed due to a well defined gully system plus an actual widening and lengthening of the flowing stream. It was surprising how quickly the restoration vegetation healed over well-defined gullies and changed the influence of a gully system as expressed by reductions in peak percentages and prolonging the period in which storm runoff drained out of the channel system. The changes in the distribution graph suggest caution in their use on evaluating land treatment measures for small watersheds.

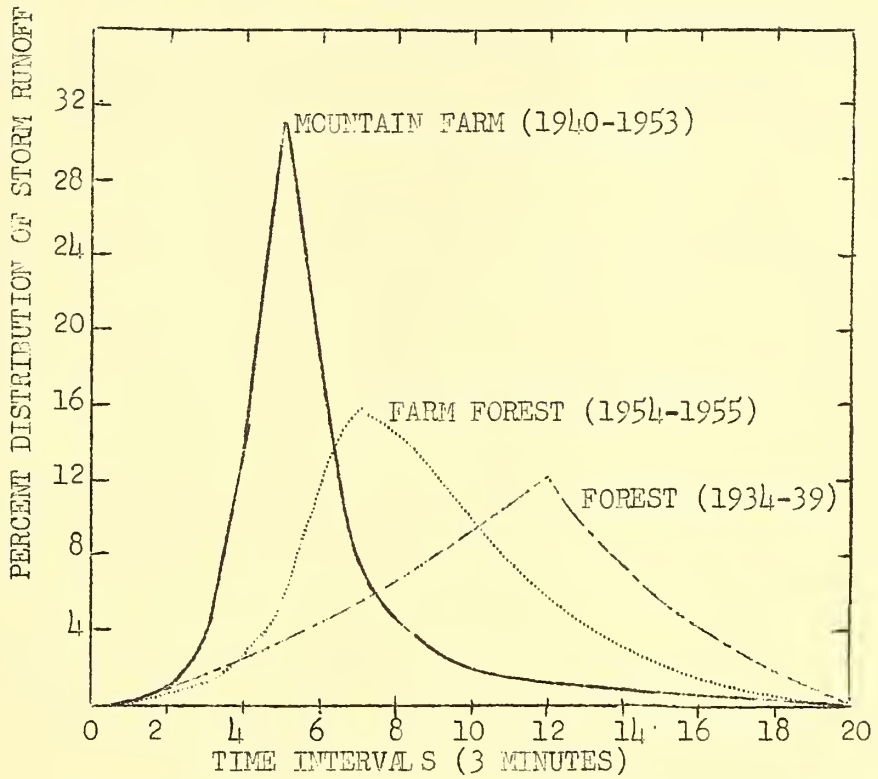


Fig 3.-- Distribution of storm runoff for an average of typical summer storms under forest cover, mountain farming and farm forestry rehabilitation practices.

Relationship Between Bulk Density and Porosity with Depth for the Porter's Stony Loam, Colluvial Phase. Watershed No. 1

Bulk density measures soil compaction by determining the oven dry weight of soil per unit volume.

Closely associated with bulk density is the proportion of large pores through which water moves under the force of gravity. The volume of these pores tend to decrease with increasing bulk density.

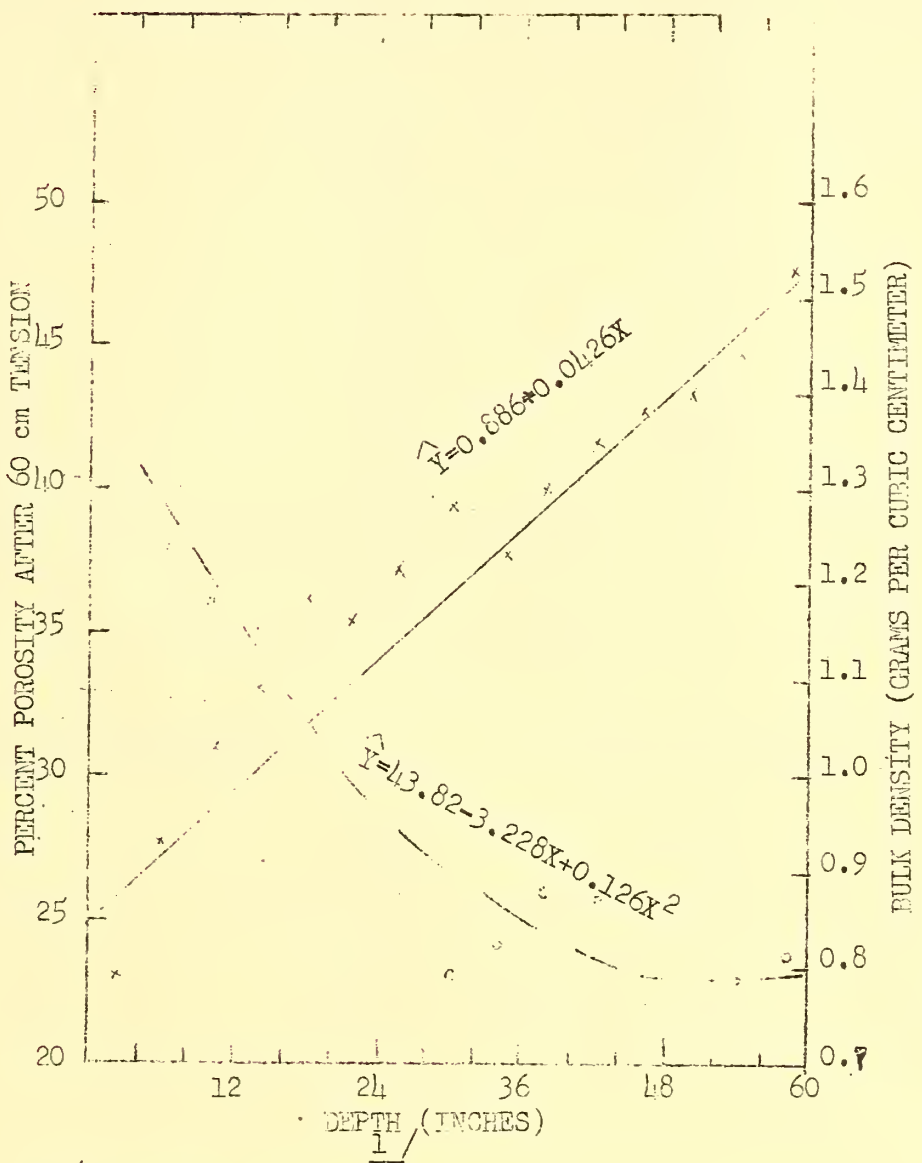
Undisturbed soil samples were collected from ten stations located along transects on the Porter's Stony Loam, Colluvial Phase soil type. Samples were extracted at 4-inch intervals to a five foot depth. The percent, per unit volume, of pores drained by a 60 cm tension was determined for each depth. It is not known whether or not the 60 cm tension drains all the large pores. However, any decrease with depth in the pores drained at a 60 cm tension should be indicative of the total volume of large pores. The data are shown in Table 1.

Analysis of variance indicated that the difference between the stations by depths was non-significant, so an average of all stations for each depth interval was used to test the relationship between bulk density and porosity with depth.

Because of equally spaced depth intervals orthogonal polynomials were used. The analysis shows a strong linear association between bulk density and porosity with depth. The quadratic effect of depth being non-significant, Table 2. Bulk density increases 0.043 grams per cubic centimeter per 4 inch increase in depth.

The test of porosity with depth, however, shows a significant linear and quadratic effect, Table 3. The porosity values decrease linearly in the A horizon, but tend to level off in the B horizon, Figure 4. The porosity values are practically constant for the 44 to 60 inch soil depths, while the bulk density values increase. It is the porosity values from 44 to 60 inches which produce the significant quadratic effect. It is felt that this phenomena may be due to the change in the proportion of various particle sizes at these depths.

These data represent but a small area. Consequently, if samples were collected over a larger area, a different relationship between porosity and bulk density with depth may be obtained. This is indicated by the dispersion of the points around the regression of porosity on depth.



1/ A-horizon 0-16 inches, B-horizon 16-60 inches

Fig 4.--Regression of bulk density and porosity (60 cm) vs depth.

Table 1.--Porosity and bulk density by depth intervals

Interval	Depth	Porosity after 60 cm	Bulk density
	Inches	Percent	Grams per cc
1	0-4	39.0	0.790
2	4-8	38.0	0.932
3	8-12	36.0	1.039
4	12-16	35.0	1.091
5	16-20	34.0	1.204
6	20-24	27.0	1.174
7	24-28	26.0	1.219
8	28-32	23.0	1.299
9	32-36	24.0	1.252
10	36-40	26.0	1.309
11	40-44	26.0	1.357
12	44-48	22.0	1.379
13	48-52	23.0	1.396
14	52-56	23.0	1.440
15	56-60	24.0	1.528
Sum		426.0	18.409
Mean		28.4	1.227

Table 2.--Analysis of variance of bulk density

Source	df	ss	M.S.
Total	14	0.552	
Due to linear	1	0.507	1/0.507
Residual	13	0.045	0.0035
Due to Quadratic	1	0.00088	0.00088
Residual	12	0.034	0.00366

1/ Highly significant

Table 3.--Analysis of variance of porosity (60 cm)

Source	df	ss	M.S.
Total	14	523.6	
Due to linear	1	412.8	1/412.8
Residual	13	110.8	8.52
Due to Quadratic	1	65.8	1/ 65.8
Residual	12	44.95	3.75

1/ Highly significant

Changes in Vegetation with Regrowth - Annual Foliage Production

In connection with the vegetation and streamflow experiment on Watershed No. 13 (July - Sept. 1955 Report), the annual production of foliage was measured by collecting the annual leaf fall in trays 34-3/4" x 34-3/4" x8" set close to the ground. The trays were randomly located on the areas. No comparative data are available for the before treatment period, although timber cruise data indicated that the forest stands on the two watersheds were similar. During 1953-1954, 14 years after the original cutting on Watershed No. 13, collections were made on the treated and control watersheds and on the boundary area of the treated watershed.

The results given below are expressed in oven dry weight of leaves per tray.

Table 4.--Leaf collection, 1953-54

Treated Watershed No. 13		Untreated Boundary area		Control Watershed No. 18	
Tray No.	Oven dry weight of leaves (Grams)	Tray No.	Oven dry weight of leaves (Grams)	Tray No.	Oven dry weight of leaves (Grams)
1	286.2	12	221.2	1	227.3
2	196.5	15	237.6	2	288.4
3	278.5	16	245.0	3	262.3
4	265.8	17	199.0	4	252.2
5	246.4	19	288.3	5	308.9
6	286.5	21	265.8	6	243.5
7	214.5			7	277.1
8	197.9			8	191.7
9	326.4			9	259.3
10	260.0			10	226.0
11	300.7				
13	215.7				
14	133.5				
18	242.2				
Aver. per day	246.5		242.8		253.7
SE	13.6		12.9		10.7
Aver. per acre	tons 1.412		tons 1.395		tons 1.453
SE	0.078		0.074		0.061

Although the stands are quite dissimilar the per acre leaf weights are not statistically different. On the control area the forest stand is all-aged with 96 sq. ft. basal area per acre with diameters up to 40 inches. On the cut watershed the basal area in 1952 was 52 sq. ft. per acre with maximum diameter of 11 inches - a 13-year-old even-aged stand of sprouts.

Cooperation

Universities

Leroy Jones received his Masters Degree at the School of Forestry, University of Georgia. His Masters Problem was "A Watershed Study in Putting a Hardwood Forest at the Coweeta Hydrologic Laboratory in the Southern Appalachian Mountains under Intensive Management."

Professor Donald Duncan, University of Minnesota, spent November 21 to December 5, becoming acquainted with procedures for analyzing watershed data and preparing data for lectures and laboratory problems in a watershed management course he gives at the University.

Little Tennessee River Watershed Association

Members of the Coweeta Laboratory assisted in the Field Examination Report under the Watershed Protection and Flood Prevention Act for the Little Tennessee River Watershed located in Rabun County, Georgia, and Macon County, North Carolina. The original application for planning assistance suggested the floodwater, sediment, and erosion problems could be corrected by application of land treatment practices, land stabilization measures and channel improvement. The SCS engineers on this Field Examination team were disturbed because there were practically no sites available for water retarding structures, and at first were reluctant in proposing this as a project. After considerable discussion it was agreed the Little Tennessee application was a worthwhile project where application of conservation measures on the land should correct most of the watershed problems.

Watershed Management Conference, Denver, Colorado

For the Watershed Conference, November 14-19, Meginnis and Johnson prepared reports under Topic III Research Contribution and Deficiencies. Meginnis discussed "Adequacy of existing provisions for extension. Are watershed research findings being applied quickly and adequately enough?" Johnson discussed "Demonstrational Value of Experimental Work and Areas."

Meginnis and Johnson attended Storey's watershed research coordination meeting November 21 and 22.

Information and Education

Johnson spent November 23 at Ann Arbor, Michigan, and spoke on"Water Resource Management and Silviculture"before the Silviculture Class, University of Michigan, and discussed Coweeta's program of Watershed Management Research at the graduate luncheon, School of Natural Resources, U. of Michigan.

Visitors

The research program was discussed in the field to 19 groups totalling 103 individuals.

Researchers have a responsibility of getting their findings into practice. Show-me-tours and visits to experimental areas are considered the most effective. For many experimental areas the trend is for an ever increasing number of visitors requesting to be shown the watershed treatments. A summary was made of groups conducted around the Coweeta Laboratory by years for 1949 to 1955 and is shown in Figure 5. From 1949 to 1955 the number of groups have doubled and if the present trend continues by 1957 there could be over 100 groups coming that year to Coweeta. Prospects for slowing down the steep rate of annual increase are not encouraging with the growing interest in water.

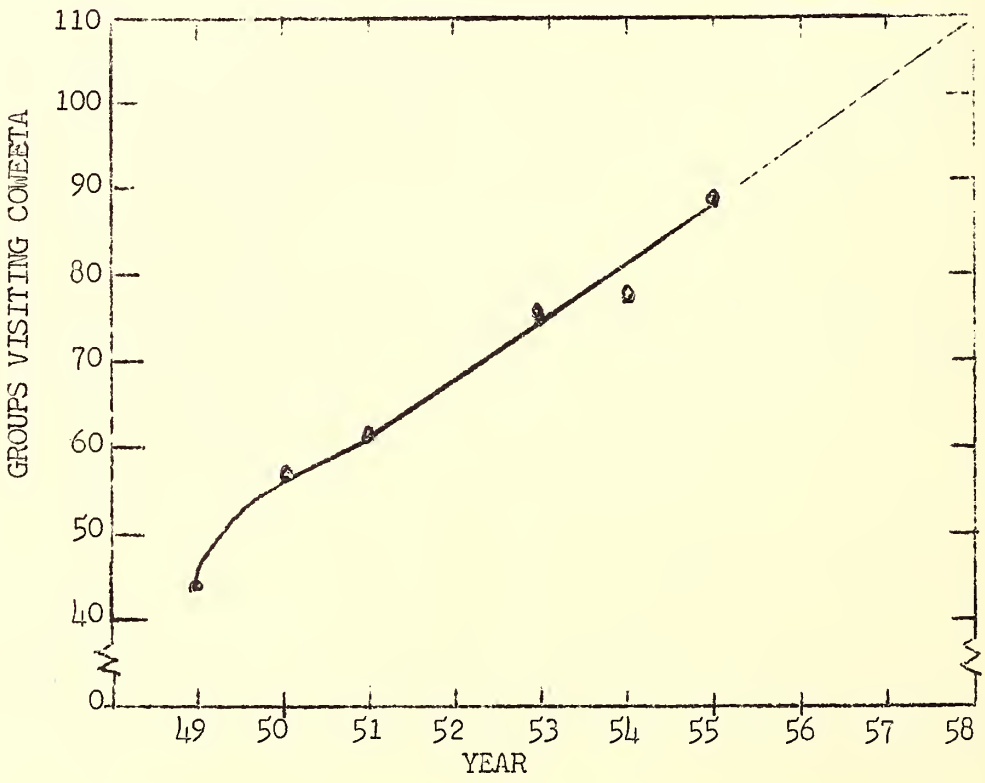


Fig. 5.-Annual number of groups visiting Coweeta. Estimated 110 groups by 1958

Table 5.--Visitors to Experimental Forests
With Watershed Management Studies
(Period January 1, 1952 to June 30, 1955)

	Total	Calhoun	Coweeta	Fernow	Fraser	Manitou	Sierra Ancha	San Dimas	Vinton Furnace	Wasatch
Foresters										
Federal										
NFA[1]	711	33	166	115	68	81	24	59	15	150
Research[1]	250	27	61	16	37	9	28	33	10	29
State	235	23	45	95	6	3	0	11	52	0
University	803	37	195	109	101	101	44	6	105	105
Industrial and private	68	11	15	22	6	2	0	0	12	0
Technicians										
USDA	315	7	44	34	14	66	16	43	4	87
U.S.D.I.	240	0	56	2	26	2	2	98	1	53
State	123	2	51	20	15	29	3	0	3	0
University (Except Foresters)	1219	4	303	2	7	3	220	369	62	249
Others	686	2	103	249	38	6	2	92	14	180
Lay Groups	3520	109	1296	88	188	344	113	434	654	294
Foreign										
Foresters	320	16	108	8	21	32	22	40	2	71
Other	317	8	108	0	6	30	10	53	0	102
Total	8807	279	2551	760	533	708	484	1238	934	1320

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
January - March 1956

DIVISION OF WATERSHED MANAGEMENT RESEARCH

SUMMARY

Coweeta Hydrologic Laboratory

	Page
Changes in seasonal streamflow following cutting of Ericaceous Understory	H-1
Some preliminary analyses for 2 seasons of effects on streamflow from deadening a cove-hardwood forest	H-3
Changes in the water balance from converting clear-cut Watershed 17 to white pine	H-6
Hydrologic Notes	
Climate	H-6
Precipitation	H-7
Cooperation	
Universities	H-8
Little Tennessee River Watershed Association	H-8
National Forests R-7, R-8	H-8
Information and Education	H-8
Visitors	H-9
Publications	H-9

Piedmont Research Center

Climatic Summary	H-10
General	H-10

Southeastern Forest Experiment Station
QUARTERLY PROGRESS REPORT
January - March 1956

DIVISION OF WATERSHED MANAGEMENT RESEARCH

COWEETA HYDROLOGIC LABORATORY

Changes in Seasonal Streamflow Following Cutting of an Ericaceous Understory

The July-September 1955 Quarterly Report discussed annual changes in streamflow after cutting a dense understory of laurel and rhododendron. Further analysis was undertaken in order to illustrate differences in the seasonal behavior of this treatment.

Growing Season - Streamflow totals for the 6-month period from May 1 to October 31 are the basis for growing season regressions. Comparison of regression lines for the two periods by the analysis of covariance showed the estimated mean increase in streamflow for the 6-year treatment period amounts to 0.79 inch and is significant at the 1-percent level with confidence limits of 0.05 to 1.52 inches.

The estimates for individual years are obtained from the regression based on the pretreatment period which is given by:

$$Y = -1.747 + 0.9945X \qquad (1)$$

Where Y equals growing-season streamflow in inches on the treated watershed, and X equals seasonal streamflow in inches on the control. The correlation coefficient is R= 0.9981, and the standard error of estimate is 0.216 inch.

Table 1.--Estimated increases in growing-season streamflow, with precipitation and time since treatment

Year	Growing season precipitation 1/ X_p	Time since treatment X_t	Estimated increases in streamflow: From equation (1) Y	From equation (2) Y
	Inches	Years	Inches	Inches
1949-50	62.90	1	0.85	1.92
1950-51	45.81	2	1.48	1.55
1951-52	38.19	3	1.39	1.17
1952-53	27.90	4	0.45	0.80
1953-54	30.80	5	0.69	0.42
1954-55	29.34	6	0.02	0.04
1955-56	45.76	7	-0.38	-0.33
Average	40.10	4.0	0.64	0.80

1/ Includes April 1-October 31 precipitation as April precipitation influences streamflow in subsequent months.

The seasonal streamflow increases for each year were obtained from equation (1) and these are shown in column 4, Table 1, together with a precipitation and time variable. Data for the 7-growing season have been included, which brings the integrated streamflow records up to date. The first year increase of 0.85 inch is considered an extreme value, as the estimated streamflow Y is widely extrapolated from equation (1). The estimate of streamflow for this year is obtained from substituting X = 35.11 inches in equation (1) which is actually based on a range of X from 12 to 23 inches in the pretreatment period. This value was omitted, therefore, and multiple regression computed from the second to seventh year data. The analysis shows the partial regression coefficient of X_t to be very highly significant, while that for X_p is not significant. This leads to the following equation for Y for the treated watershed.

$$Y = 2.301 - 0.3763X_t \qquad (2)$$

Correlation coefficient R is 0.9535 and the standard error of estimate is 0.288 inch.

The estimated increases in streamflow in column 5 of Table 1 are obtained from equation (2). The average increase for the first 6 years amounts to 0.98 inch. This includes the estimate for the first year, which is extrapolated from equation (2). The effect of regrowth on streamflow was evident in column 5, Table 1, with the regression analysis showing the time trend as statistically significant. In contrast with the annual results (reported in 1955) the increases in growing season streamflow are independent of the amount of precipitation.

Dormant Season - The dormant season regression, November 1 to April 30, for the pretreatment period is given by:

$$Y = 1.848 + 0.8803X \qquad (3)$$

where Y equals seasonal streamflow in inches on the trested watershed and X equals seasonal streamflow in inches on the control. The correlation coefficient R = 0.9985 is highly significant and the standard error of estimate is 0.142 inch. The estimated average increase in streamflow for the treatment period as obtained by the covariance analysis is 1.00 inch, which is significant at the 1-percent limit with confidence limits of 0.28 to 1.72 inches.

Table 2.--Estimated increases in dormant-season streamflow, with precipitation and time since treatment

Year	Dormant season precipitation 1/ X_p	Time since treatment X_t	Estimated increases in streamflow From equation (3) Y	From equation (4) Y
	Inches	Years	Inches	Inches
1949-50	49.76	1	1.74	1.42
1950-51	40.08	2	0.40	0.58
1951-52	60.57	3	1.63	1.79
1952-53	49.49	4	0.62	0.86
1953-54	54.77	5	1.12	1.04
1954-55	47.30	6	0.54	0.36
Average	50.33	3.5	1.01	1.01

1/ October 1 to April 30

Since October rainfall strongly influences subsequent seasonal streamflow, it has been included in the seasonal precipitation, that is October 1, to April 30. The derived multiple regression, including a time and precipitation variable, is given by:

$$Y = -1.785 + 0.6789X_p - 0.1785X_t \qquad (4)$$

The multiple correlation coefficient R = 0.918 just fails to reach the 5-percent significant level, and the standard error of estimate is 0.259 inch. The partial regression coefficient of X_p is significant at the 5-percent level, and that of X_t is significant at the 10-percent level. The regression estimated are shown in column 5, Table 2. It is quite likely that with additional data the time trend will be more clearly defined. Increases in streamflow for this season are apparently related to precipitation.

Some preliminary analysis for 2 seasons of effects on streamflow from deadening a cove-hardwood forest

Limited information is available on the influence of various hardwood forest types upon streamflow. The 1954 Program Conference at Coweeta recommended obtaining comparative data for the different regional forest types. The first study in this series was initiated in 1954 to determine the extent to which cutting a cove-hardwood forest vegetation would change streamflow. The cove-hardwood forest type is found on deep, moist, fertile sites which parallel the stream channels. Included in this forest type is the true riparian vegetation. The root system is deep and withdrawal of soil moisture has been measured at the 7-foot depth.

In this particular study Watershed 1 was selected for treatment and Watershed 2 was the control as shown in Figure 1. The deadening treatment applied in March 1954 consisted of deep girdling all woody vegetation 4 inches d.b.h. or larger, and then applying silvicides to the girdled area. Woody vegetation less than 4 inches d.b.h. was cut close to the ground with hand tools and the stumps painted with silvicides.

A total of 9.7 acres or 25.03 percent of the land area within Watershed 1 was treated (Fig. 1). Length of the treated area is 2550 feet and the width varies from 60 to 330 feet.

Prior to treatment a complete tally was made of all woody vegetation 0.5 inches d.b.h. and larger by species by diameter classes. This tally indicated the cove-site forest stand as having a basal area of 77.67 sq. ft. per acre. Hickory, red maple, white oak, yellow poplar, and dogwood together comprised 54.3 percent of the basal area.

The technique of covariance analysis was used to analyze the monthly streamflow, and to compute regression equations for each month. The differences between observed and predicted streamflow from the treated watershed provides an estimate of the effects on streamflow of deadening a hardwood vegetation and are given in Table 3. Data for the season of groundwater recharge has not been included since only 1-year of record was available and integrator computations are incomplete for the second year.

Table 3.--Average monthly precipitation and streamflow for the hydrologic seasons of maximum evapotranspiration and soil moisture recharge for the period 1954 and 1955

	Precipitation	Streamflow			
		Observed	Estimated	Gains	Standard error of estimate 3/
	Inches	Inches	Inches	Inches	Inches
May	7.40	4.27	4.22	0.05	0.182
June	4.47	3.02	2.37	0.65 1/	0.177
July	6.63	2.51	2.08	0.43 1/	0.178
Aug	4.39	1.89	1.51	0.38 1/	0.180
Sept	1.66	1.26	0.88	0.38 1/	0.178
Oct	2.34	1.11	1.06	0.06	0.177
Nov	4.24	1.26	0.91	0.34 2/	0.165
Dec	5.88	1.40	1.24	0.16	0.164

1/ Significant at the 1-percent level
2/ Significant at the 5-percent level
3/ 46 degrees of freedom for each estimate

Average increases in water yield for the 2 hydrologic seasons in the two-year treatment period amounts to 2.3 area inches. Assuming this increase in yield is proportional to area cut, a maximum 8-months yield of 9.1 area inches could be expected if the entire watershed had been treated. This value, however, may be high considering that the cove hardwoods probably consume more water than the regional forest types located on slopes and ridges. For those who are comparing these unit gains in streamflow with reports from other Coweeta studies we would like to point out that previous treatments are on north facing areas while this is the first water yield treatment on a south facing watershed. During the growing season, the months of May and October did not show a significant increase, and during the soil moisture recharge season November is the only month with a significant increase (Table 3).

With the exception of the riparian vegetation, increases in streamflow are due to the decreased soil moisture deficits. This larger volume of water remaining in storage is the result of the removal of transpiration by the cove-site vegetation. Consequently, the pattern of precipitation will determine the magnitude of the monthly increases in streamflow. Moreover, there is a carry over effect of the precipitation falling in one month and appearing as streamflow in the following month.

An average of precipitation and increased water yields for 1954 and 1955 indicates that the soil moisture deficit was not fully recharged during the growing season. However, enough precipitation fell in November each year to satisfy the deficit, reculting in an increased water yield for this month.

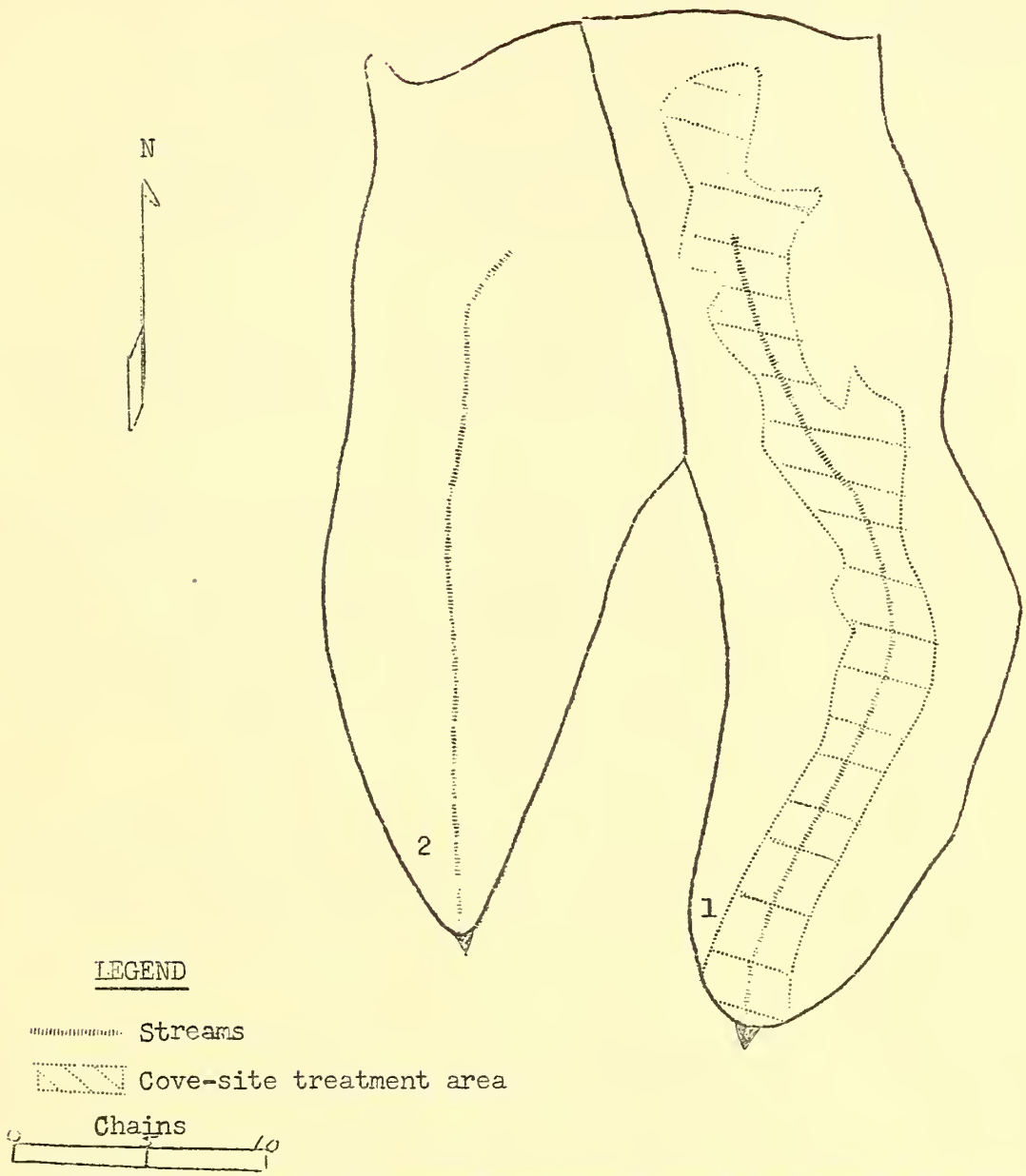


Figure 1.-- Map of 39-acre watershed 1 where the cove-hardwood forest type was treated and the 31-acre watershed 2 (control).

Changes in the water balance from converting clear cut Watershed 17 to White pine

Last fall preparations were made for planting white pine on the clear-cut experimental watershed 17. The experiment to study the effect of clear cutting on streamflow was terminated in 1954. With two years' growth of sprouts and herbaceous material on the area, planting would be a difficult operation, and the natural vegetation would probably crowd out the young pines.

To increase planting efficiency, the vegetation on the area was cut down during the fall of 1955. This operation differed in no respect from the regular cutting treatment which aimed at maintaining the watershed in a field condition. It may be noted that after 12 years of repeated cutting the woody sprouts were still quite vigorous; black locust was over 10' tall and 2" in diameter at the stump.

Following this operation all the cut woody stems and stumps were hand sprayed with a solution of 2-4-5T in fuel oil. The idea is to reduce the vigor of sprouting or possibly kill this vegetation which would offer the most serious competition to the white pine. The herbaceous material should be less of an obstacle.

A crew of 5 men using back pack sprayers were assigned to the job. The spray was directed from the top of the cut stem down to and around the ground line so that all exposed parts of the vegetation were adequately covered with the spray as well as some of the surface roots. It required 900 gallons of the mixture to treat approximately 40 acres. The full effect of the treatment may not be known for several growing seasons although the laurel and rhododendron sprouts appear in poor condition. It is expected that additional cutting will be necessary in subsequent years in order to establish the white pine on the area.

Planting of white pine, 2-0 stock, was begun on February 13, 1956 about two months after completion of spraying. 6 x 8 spacing was selected. Mattocks were used due to the steep and rocky nature of the watershed. The planting was completed on March 29 using a total of 33,000 plants.

Hydrologic Notes

Climate

Air temperatures for the first quarter were below normal. January had several extended periods of subfreezing temperatures. During these periods soil on the mountain farm froze to 3 inches which is the maximum depth we have observed in recent years. Usually there are warm periods in February and March that advances vegetative growth, but this year the cool temperatures in March delayed tree, flowering shrubs and spring flower development around two weeks.

Table 4.--Climatic summary of air temperatures and evaporation - WS 1

	Average		Maximum		Minimum		Evaporation	
	1956	Dev from Normal	1956	Dev from Normal	1956	Dev from Normal	1956	Dev from Normal
Jan	36.3	-3.9	48.7	-2.4	23.9	-5.4	.36	-.59
Feb	45.1	+4.1	55.8	+2.8	34.3	+5.4	1.13	-.54
Mar	46.2	+0.7	60.3	+0.4	32.2	-1.7	2.33	-.49
Average	42.5	-0.2	54.9	+0.2	30.1	-1.6	1.27	-.48

Precipitation

The general precipitation deficit that started in June 1955 continued through January 1956. This resulted in January streamflow on the lower elevation watersheds and at the 1800-acre gaging stations being 60 to 70 percent of normal. The 6-inch surplus precipitation in February recharged soil moisture and returned ground water elevations to normal for this season.

Table 5.--Precipitation summary

	1956	Deviation from normal
January	2.48	-4.85
February	13.13	+6.27
March	6.64	-1.22
Quarterly Total	22.25	+ .20
Water year to 3/31	28.54	-5.22

Precipitation in the Tennessee River Basin for the 8-months June 1955 through January 1956 was the fifth lowest in 66 years of record. During the 21 years Coweeta has operated, only two other June-January periods recorded less rainfall than in the period ending this quarter. The following table lists, for the Tennessee River above Chattanooga, the June-January periods in the past 66 years with rainfall equal to or less than in 1955-56 and the corresponding amounts recorded at two Coweeta watersheds.

Table 6.--Comparison of low precipitation period June through January for 1890-1956 on the Tennessee River above Chattanooga and two Coweeta watersheds for 1935-56

Order of Increasing Magnitude	Tennessee River above Chattanooga		Coweeta Watersheds: Low Elevation WS 1		High Elevation WS 28	
	Period	8-month total	Period	8-month total	Period	8-month total
		Inches		Inches		Inches
1	1939-40	22.00	1939-40	26.14	1939-40	30.25
2.	1930-31	23.35	- -	- -	- -	- -
3.	1913-14	24.16	- -	- -	- -	- -
4	1933-34	25.07	- -	- -	- -	- -
5	1954-55	25.10	1954-55	30.46	1954-55	42.81
6	1904-05	25.38	- -	- -	- -	- -
7	1895-96	25.58	- -	- -	- -	- -
8	1955-56	25.62	1955-56	32.71	1955-56	44.92
Average		32.81		42.79		56.31

Cooperation

Universities

Two of Coweeta's co-op forestry students graduated from forestry school during the quarter. LeRoy Jones received an M.F. at the University of Georgia, and Willie Curtis a B.S.F. at North Carolina State College. Both individuals have decided to become Forest Service career employees with Jones accepting a position on the Tallulah Ranger District, Chattahoochee National Forest and Curtis reporting March 1 to the Manitou Experimental Forest, Rocky Mountain Station.

Preliminary arrangements were made this quarter for 2 Masters Thesis projects with the School of Natural Resources, University of Michigan.

Little Tennessee River Watershed Association

The application for Assistance in Planning and Carrying out Works of Improvement under Public Law 566 was approved by the North Carolina State Committee and forwarded to Washington.

National Forests

R-7

Johnson and Meginnis spent February 20 to 25 on a tour to the George Washington and Jefferson National Forests arranging for a pilot-type demonstration study in cooperation with National Forest Administration, on location and layout of logging roads to minimize watershed damage. Black's Run on the Dry River District, George Washington National Forest was examined as a possible study area. Estimates were that a sale on this area would be around 2 to 3 million board feet. Supervisor Anderson has arranged to have the timber marked and a provisional road system located on the ground by late Spring.

R-8

The study in cooperation with R-8 and the Chattahoochee National Forest on location and layout of logging roads to minimize watershed damage has progressed very well. Excellent cooperation by Supervisor Newnham resulted in completion this quarter of: marking, field location of all logging roads, preparation of appraisal report, and in preparing a detail logging plan for the area. It is contemplated that active logging will commence in April.

At the request of the North Carolina National Forests, Johnson spent March 2 examining a timber sale where the North Carolina Wildlife Resources Commission contended logging would damage water quality at one of their trout hatcheries. This is the second request in a few months where the North Carolina State Fish Division has created an issue on logging effects upon water quality where Research was called upon to provide advice and assistance.

Information and Education

General training sessions were privided for research personnel from the Department of Lands and Forests, Maple, Ontario; and Abdurahman Ereke from Bolu, Turkey.

Jim Douglass, Piedmont Research Center spent 3 days here on hydrograph analysis training.

Visitors

The first quarter of the year usually provides a breather from the heavy visitor schedule. There were 24 people shown the area and they came in 11 groups. We enjoyed the visit and discussions with Regional Forester Olson, Director Bailey, Assistant Regional Foresters Grefe, Standing and Van Meter, and Gano from the Washington Office.

Publications

Manuscript accepted for publication

Johnson, E. A. and Dils, R. E.
"Outline for Compiling Precipitation, Runoff and Groundwater from Small Drainage Areas" has been accepted for publication as a Station Paper.

New Manuscripts

Johnson, E. A. and Kovner, J. L.
"Effects on Streamflow of Cutting a Forest Understory", scheduled for publication in Forest Science was reviewed by Dunford, Hoover, Lull and Rowe. We appreciate the many suggestions made by the reviewers for strengthening and clarifying the manuscript. Most of their comments were used and a revised manuscript is scheduled for submission to Forest Science by April 10.

Kovner, J. L.
"Statistical Analysis of Precipitation, Streamflow and Groundwater from Small Drainage Areas"

New Literature Reviews by Kovner

Handbook of Statistical Methods in Meteorology by C.E.P. Brooks and N. Carruthers 1953 Her Majesty's Stationery Office York House, Kingsway, London, W.C. 2 Price - £ 1 5s 0d net

The reviewer has not had time to examine this book in detail, but an initial reading indicated that it is a useful addition to the list of statistical texts. The need for this book arises from the special nature of field observations encountered in meteorology and climatology. The same kind of observational data arises in many of the geophysical sciences. Workers in the fields of forest hydrology and ecology, for example, will find this book a handy reference text.

The text is not uniform, however, and some sections are quite simple while others will require a more advanced knowledge of statistical methods. It is felt that the chapters on frequency distributions are easy to understand and will be very helpful and informative.

PIEDMONT RESEARCH CENTER

January - March 1956

Climatic Summary

December was very dry, the rainfall occurring mostly at the beginning of the month.

January rainfall was also less than normal, rainfall from December 10 to January 19 (a total of 40 days) was only .04 inch.

February was excessively wet, having a total of 7.83 inches, a record rainfall for February since the station was established in 1947.

March was about normal in rainfall and temperatures.

Quarterly Climatic Summary - Calhoun Experimental Forest

Month	Average temperatures			Highest temp.	Lowest temp.	No. of days with rain	Precip.	Evap.
	Max.	Min.	Mean					
	°F	°F	°F	°F	°F		Inches	Inches
December	51	27	39	72	12	6	.32	1.30
January	53	25	39	68	14	6	2.22	1.49
February	60	36	48	75	21	16	7.83	2.10
March	64	37	50	82	19	13	4.42	4.00

General

James E. Douglass, a graduate of Auburn and Michigan State, reported for work in watershed management on January 3. Douglass spent 3 days at Coweeta on a training assignment.

No new project work started in Watershed Management this quarter. Some time was spent in analyzing soil moisture work and Douglass began working on the data from the 4 weirs on the Calhoun Experimental Forest.

SEMI-ANNUAL REPORT
Forest Influences Research
Southern Forest Experiment Station

October 1955 - March 1956

Vicksburg Infiltration Project

The activities of the Vicksburg Project centered upon data analysis and report preparation during the last six months. The collection of field data for the comparison of soil moisture of cultivated and non-cultivated areas was completed in February, leaving the Tropical Extension in Puerto Rico as the only field activity. This work will continue until the soils are wetted to field maximum by late spring or early summer rains.

Data from all sites with detailed records of soil-moisture have been processed for publication and for further correlation studies. These data will form the basis for derivation of standard wetting and drying relations which, it is hoped, will make possible reliable off-site prediction of soil moisture. Data from the sites studied in the soil-strength-moisture survey have likewise been summarized for publication.

Analysis was initiated at the Statistical Laboratory at Purdue University to correlate accretion and depletion relations of soil and site characteristics from 106 sites having detailed records. The goal is to derive standard equations from which prediction of soil moisture at any location can be approximated from knowledge of soil and site characteristics. Dr. Louis J. Cote has been assigned to advise in statistical procedures and to make the final analyses following machine computations.

An initial analysis using a digital computer has been made with the slopes and intercepts of the Class I (storms with rainfall amounts less than the amount of available storage space for moisture in the soil) accretion regressions of the 0 to 6-inch layers against 18 factors simultaneously. Subanalyses will be made on these 18 factors and other classification variables to determine which contribute significantly towards the regression. Similar analyses will be made for Class II (storms with rainfall more than available storage space) accretion regressions as well as depletion relations and the field maximum and field minimum moisture contents. Data from all sites have been punched on cards for sorting and subanalyses.

Further predictions of soil moisture at the survey sites discussed in the April-September report have not been made except to finish those which had incomplete rainfall records and to make certain corrections. In general, the deviations of predicted from the actual remain about the same. It is hoped that by use of more refined prediction relations developed at Purdue, that these deviations can be materially reduced.

Soil trafficability maps, based on soil associations, were prepared for the four regions covered in the soil-strength-moisture surveys. Maps were drawn for a total of 19 states and degrees of trafficability indicated for the wettest season.

Cultivation Study

Analysis of data has begun for the soil moisture study of cultivated versus non-cultivated areas. Duplicate plots of four treatments each were used in the study. The treatments were: bared, natural grass, once cultivated (March 2, 1955), and frequently cultivated (3/2, 4/19, 5/18, 7/1, and 8/5). Periodically, all vegetated plots were clipped to a height of three inches.

Following the one cultivation, vegetation on the once-cultivated plot stooled out better and was more vigorous than that with other treatments. Early in the growing season, its vegetation was 15 - 20 inches high as compared to 6 - 8 inches on the other vegetated plots, before clipping.

Bulk-density samples of the 0 to 3-, 3 to 6-, 6 to 9-, and 9 to 12-inch layers were taken in duplicate for each treatment on five dates. For practical purposes they showed no differences in bulk density by treatment or date.

Random gravimetric soil-moisture measurements were made weekly for each treatment. Figure 1 shows the moisture record of the 6 to 12-inch layer on a bimonthly basis for the first six months of the study. Similarity in moisture changes between natural and frequently-cultivated treatments is immediately apparent. The moisture in the once-cultivated plots shows a more rapid depletion rate probably because of the stimulated vegetation growth. Slower rates of moisture loss occurred in the bare plot and therefore moisture was generally higher. Moisture in the 12 to 18-inch layer followed the same pattern as the 6 to 12-inch layer but in the 0 to 6-inch layer, vegetation or treatments had little influence on drying rates.

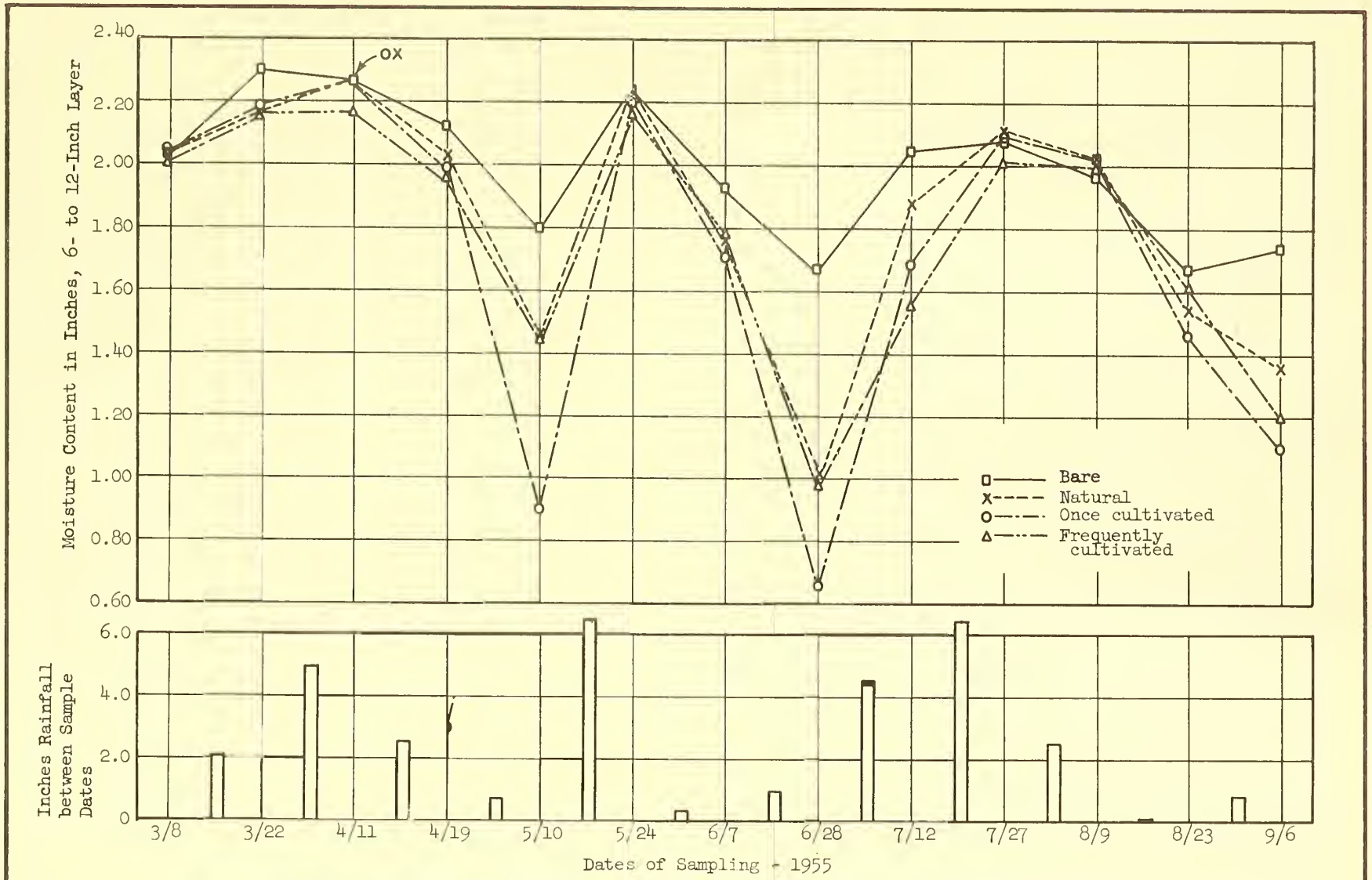


FIGURE 1. SOIL-MOISTURE RECORD AT CULTIVATION TEST PLOTS, 6- TO 12-INCH SOIL LAYER

The principal objective of the study was to determine if the prediction relations from a vegetated area can be used to predict soil moisture in cultivated areas of similar soil. The moisture regime exhibited here indicate that the moisture content in the surface foot of cultivated areas can be predicted from relations derived from undisturbed areas for this type of soil, vegetation, and climate. There seems to be no justification for the derivation of special relations to be used in cultivated areas. A correction, of course, would have to be made for areas kept completely free of any vegetation.

The permanency of the Colman fiberglas unit installations has often been discussed. Recently, a check was made on two stacks installed in a pine plantation adjacent to the Waterways Experiment Station on March 31, 1952. They were operated for one year and then the installation abandoned with the units left in the soil. On March 19, 1956, resistance readings and gravimetric samples were taken with the following results expressed as percent moisture by volume:

Depth Inches	Stack 1		Stack 2	
	Gravimetric	Unit	Gravimetric	Unit
	... Percent moisture by volume ...			
0 - 3	31.7	-	41.7	32.3
3 - 6	34.0	-	35.7	32.7
6 - 9	36.0	34.0	38.5	32.7
9 - 12	35.7	-	37.7	34.0
12 - 15	38.0	38.0	38.3	35.3
15 - 18	37.7	37.7	38.7	37.3
18 - 21	37.7	39.7	38.7	35.3
21 - 24	38.0	39.0	39.3	39.3
27 - 33	38.3	16.3	36.3	35.7
39 - 45	27.7	-	16.2	16.7
51 - 57	17.3	16.7	18.7	17.3

Four units of Stack 1 did not function. This was probably due to damage to the lead wires, as the switch box was broken off from the post and lying on the ground. In general, agreement between gravimetric and unit measurements is excellent, indicating that the units were still functioning and that the calibration curves have not shifted in the four years since installation.

The following comparison of soil moisture by foot increments shows that dry conditions can be a major factor in the deeper soil layers under pine.

Depth feet	April 1952*	March 1953	March 1956
	- Percent moisture by volume -		
0 - 1	31.4	33.2	32.9
1 - 2	31.2	37.8	36.8
2 - 3	24.7	30.3	35.7
3 - 4	15.9	38.3	16.7
4 - 5	17.0	17.3	17.3

*After some spring depletion.

The 1956 values agree with those of 1952 and 1953. The 4 to 5-foot layer stays consistently at a wilting point of about 17 percent and the 3 to 4-foot layer is usually about as dry. The .06 atm. tension value is about 42.5 percent and the total pore space about 45.8 percent by volume. The soil never wet to these values indicating that a perched water table was not formed. The dry layers, therefore, are not below a pan or a layer of very low permeability. The dry lower layers are especially surprising in 1956 as we had 16.25 inches of rainfall from January 21 to March 15 measured in the Waterways Experiment Station gage. Normally this should be enough water to wet the profile six feet and more.

The lost water can probably be attributed to high runoff. Though the pine plantation had been established about 18 years ago in a gullied field, the accumulated litter has apparently not yet increased infiltration sufficiently to prevent excessive runoff.

Publications

Lull, H. W., and Reinhart, K. G. Soil-moisture measurement. Southern Forest Experiment Station Occasional Paper 140, 56 pp., illus. 1955.

Horton, J. S. Use of electrical soil-moisture units in mountain soils. Proceedings, 23rd Annual Meeting, Western Snow Conference, pp. 20-26, illus. 1955.

Manuscripts being published

Carlson, C. A., Reinhart, K. G., and Horton, J. S. Predicting soil moisture in the surface foot of soil. To be published in Soil Science Society of America Proceedings, Vol. 20, No. 3, July 1956.

Manuscripts being edited

Doss, B. D., and Broadfoot, W. M. Properties of 91 southern soil series. Should soon be ready for publication as an Occasional Paper of the Southern Forest Experiment Station. The tables will be prepared and printed by Waterways Experiment Station. As soon as this paper receives final editing in New Orleans, similar papers will be prepared for the soil series studied by the Lake States, Intermountain, and Northeastern soil strength-moisture Surveys of the Vicksburg Infiltration Project.

Progress Report 4, which summarizes the site characteristics, soil properties, and prediction relations for all sites for which the Project has accumulated detailed soil-moisture and climatic records, is now being prepared by the Waterways Experiment Station for printing.

Manuscripts in Preparation

Carlson, Charles A. Estimation of the field maximum moisture content. Equations have been derived from data obtained from sites with detailed moisture records relating the field-maximum moisture content to the texture, organic matter content, and wetness index of the 0- to 6-inch and 6 to 12-inch soil layers. The accuracy of these equations is now being tested against the data from over 500 survey sites located throughout the United States. Results will be presented at the November 1956 meeting of the Soil Science Society of America and a paper published shortly thereafter in the Proceedings of that Society.

Thames has completed preliminary analysis of data for a proposed paper which summarizes the results of studies using the record obtained with fiberglas soil-moisture units installed at one site to predict soil moisture at widely-separated sites where infrequent gravimetric samples have been taken. The relationship of the unit readings and the gravimetric data are used as a basis for the prediction of detailed soil-moisture readings at the non-unit sites. So far, provided rainfall amounts are about the same, good correlation has been shown, even between locations differing somewhat in soil type and plant cover.

Tallahatchie Research Center

Watershed Management Research in the Midsouth--Project Analysis

An analysis of watershed conditions and research needs in north Mississippi for the Yazoo-Little Tallahatchie Flood Prevention Project particularly, and the Midsouth generally, was completed and approved in January 1956. It is presently in in-Service review.

The general types of information needed and proposed for research investigation have been previously described. Studies proposed to help solve watershed management problems in the immediate future are grouped under Land Rehabilitation and Hydrologic Studies.

Proposed land rehabilitation studies include: (1) developing methods to classify adverse sites; (2) species-site adaptability on adverse sites; (3) mulch requirements for pine establishment on adverse sites; (4) comparative effectiveness of different mulching materials for pine establishment on adverse sites; (5) pine litter required to halt soil movement; (6) effects of spacing on litter accumulation under pine plantations; (7) effect of physiological grades of stock in planting adverse sites; (9) developing special stock for gully planting; (10) soil-collecting trenches and post holes for gully planting; and (11) effects of transpiration inhibitors on loblolly seedlings used in gully planting.

Hydrologic studies proposed include: (1) rates of runoff and erosion from major soil-cover complexes in the Midsouth; (2) deceleration of runoff and erosion following land treatment; (3) hydrologic effects of various intensities of thinning pine plantations; (4) hydrologic effects of mulch; (5) hydrologic effects of species conversion; (5) sediment deposition rates and patterns; (6) hydrologic effects of various intensities of pine sawtimber harvest cutting; (7) effects of rainfall characteristics on runoff and erosion; (8) hydrologic effects of woodland burning; (9) hydrologic effects of woodland grazing; and (10) inherent physical characteristics of major soils affecting relative erodability.

Current Studies

Seven new watershed management study plans were prepared. One is pending approval, four were approved and the studies installed, and two were approved for installation during the 1956-1957 planting season. These studies are in cooperation with the Yazoo-Little Tallahatchie Flood Prevention Project. Following is a brief description of the scope and status of each study.

Rates of Runoff and Erosion from Major Soil-Cover Complexes in the Midsouth.--A study plan designed to determine rates of surficial runoff and soil loss from major soil-cover complexes in the Midsouth was completed and submitted for approval in March 1956. This will be a continuing study. Watersheds will be small natural catchments a few acres in size. Surface runoff will be measured with H-type flumes. Soil loss will be measured with a fractional wheel sampler devised at Coshocton. Soil moisture will be followed with Colman units and gravimetric methods. Watershed units will be installed in batteries of three. This will be done to strengthen and substantiate runoff-erosion data for a given complex, and to calibrate each battery for subsequent studies. Two batteries on one major soil group are proposed for installation prior to the 1957 water year. Three units will be installed on eroded, old-field conditions. After suitable calibration this battery will be used in a study to determine deceleration of runoff and erosion rates through remedial treatment. The other battery of three watershed units will be installed on depleted hardwood types with sparse litter cover and active erosion. Typically these areas are largely composed of culls and uncommercial species and are poorly stocked. This condition is represented on many thousands of acres in the Midsouth. After calibration the hydrologic effects of conversion to pine will be tested.

Degree of Root Pruning.--A cooperative study to compare early survival and height growth of loblolly pine seedlings pruned to different root lengths was established in February 1956. Treatments include roots pruned to four different lengths, unpruned seedlings, and two methods of planting unpruned seedlings. Trees were outplanted in three randomized blocks on a sandy, eroded site.

Mulch Requirements for Pine Establishment.--A cooperative study to compare the effects of mulch on initial survival and early development of loblolly pine seedlings planted on adverse sites in north Mississippi was installed in February 1956. Two rates and two methods of application are being tested on three eroded site conditions in a replicated and randomized block design.

Morphological Grades of Loblolly Pine.--A cooperative study to compare initial survival and early field performance of three morphological grades of loblolly pine seedlings planted on an adverse site was established in February 1956. Planted were grade one, grade two, and grade three seedlings. The latter are generally the smaller and weaker stemmed seedlings shipped after culling at the nursery. Outplanting was done in three randomized blocks.

Post Hole Plantings as an Aid in Revegetating Eroded Lands.--A replicated study to determine the effect of six methods of preplanting site preparation and planting upon survival and growth of loblolly pine seedlings planted on eroded, exposed Coastal Plains subsoil was installed during January and February 1956. Treatments tested include: (1) mattock planting and (2) mattock planting in combination with spot mulching around the seedling. The remaining four treatments are post hole treatments. Seedlings are planted in post holes 6 inches in diameter and 24 inches deep. All post holes are filled with topsoil obtained from nearby locations. Treatments are as follows: (1) fertilizer applied at 24-inch depth; (2) fertilizer applied at 24-inch depth and seedling spot mulches; (3) seedling planted in topsoil-filled hole, no other treatment; and (4) seedling planted in filled hole and spot mulched.

Soil collection trench use in revegetating eroded land.--A replicated study designed to determine the effect upon survival and growth of loblolly pine seedlings planted in trenches which have filled with alluvial material. Trenches were installed during December and January 1955 and 1956 on eroded Coastal Plain subsoil. Seedlings will be planted during the 1956-1957 planting season after trenches have filled with alluvium.

Species Adaptability on Adverse Sites.--Virginia, sand, races of loblolly and races of shortleaf pine which have demonstrated drouth resistance on good sites will be tested on Coastal Plain subsoil and deep sands for drouth resistance. Seed for species and races to be tested have been gathered and seedlings will be grown in one nursery during the 1956 season. Outplanting in north Mississippi will be accomplished during the 1956-1957 planting season.

Details of current soil-site studies have been previously described. Following is a progress report on established studies including two recently installed.

Grasses and Legumes for Erosion Control.--A study to determine the effects of selected grasses and legumes on soil hydrologic properties was established in north Mississippi in January 1955. The heavy rains in early 1955 badly damaged much of the planting which were replaced this fall and winter. As a safeguard against a recurrence of heavy rains, the plots were lightly mulched and some diversion ditches were prepared. Weeping lovegrass (Eragrostis curvula) made a good showing in nearly all plantings, and required only light reinforcement.

Pine Response to Fertilizer.--A study to determine the effects of single and repeated fertilizer applications on survival and growth of loblolly pine seedlings planted on severely sheet eroded sites was reestablished in April 1955. First-year results indicate no significant effects on first-year survival of the pine seedlings due to a single fertilizer application. Seedling loss was five percent greater on loess than on sand.

Pine response to Legumes.--A study was reinstalled in north Mississippi in March 1955 to determine the response of loblolly pine seedlings planted on adverse sites to interplanted legumes. Legume plantings were reinforced this fall and winter as needed. After one growing season, there was no demonstrable effect on loblolly pine seedlings caused by interplanted legumes.

Soil Moisture and Tree Growth.--A cooperative study was installed in north Mississippi in April 1954 to determine the relationships between tree growth and soil moisture content as it varies from day to day and season to season; also to obtain soil and soil moisture data for the Vicksburg Infiltration Project. The field and analytical work have been completed on this study. The results are now being prepared for publication.

Site Changes with Species Conversion.--A study was installed in north Mississippi in March 1954 to determine the nature, rate, and extent of site changes--especially those affecting infiltration and retention of water--associated with conversion of ridge stands of worthless hardwoods to pine. Survival and growth of the planted pines has been excellent. The few trees lost to the falling of the deadened overstory and to grass competition have been replaced by trees planted in the isolation strips. Soil physical properties will be remeasured this fall.

Soil Moisture Variations with Ridge Conversion.--This study is designed to determine the variations in soil moisture content on blackjack-post oak ridges when the ridges are converted to pine with different intensities of hardwood removal. Samples to determine present soil physical properties are now being taken. The periodic soil moisture sampling also has begun.

Moisture and Growth Changes with Thinning.--This study is designed to determine the changes in soil moisture content and tree radial growth that are associated with thinning. Two of the three blocks in the study have been thinned back to a basal area between 75 and 80 square feet. The third block is unchanged. Moisture and growth measurements have begun and will continue through the growing season.

East Texas Research Center

Current work at East Texas Research Center with watershed implications is confined to a single study, ET 10.8-- Effects of prescribed burning on soil-water relations of east Texas forest soils.

This study, which was installed in 1952, is concerned with the evaluation of the effects of prescribed burning on site and soil-water relations for three of the soil series found in east Texas: Boswell very fine sandy loam, Sawyer very fine sandy loam, and Huckabee loamy fine sand.

Paired plots were located on each of the three soils, and each plot contains a 4-foot by 20-foot runoff plot. On two locations a recording device is available to measure the intensity and duration of runoff, while at the other location runoff is measured volumetrically after each rain. Each plot has a tier of 10 Colman units at depths to 66 inches. At each location is a recording rain gauge to measure the intensity and duration of rainfall.

Daily measurements of soil moisture and temperature changes were made on the undisturbed plots for 1-1/2 years in an attempt to calibrate their inherent differences. At the end of that time one of each of the paired plots was prescribed burned, following the prevailing practice. Measurements were continued and in addition weekly dial dendrometer readings were taken on selected pine trees to determine possible effect of changes in soil moisture on tree growth.

At the end of the third year moisture and temperature measurements were reduced to three times weekly.

Plans call for a progress report to be prepared during the calendar year to cover the first three years of the study..

SEMIANNUAL REPORT
WATERSHED MANAGEMENT RESEARCH
TROPICAL FOREST RESEARCH CENTER
October 1955-April 1956

Watershed Research, other than some preliminary plans for a problem analysis, has been restricted to the Tropical Extension of the Vicksburg Infiltration Project. Though the primary purpose of the project is ".... to develop soil-moisture prediction methods and moisture-soil strength relationships...", some of the data collected and the methods used may be employed in future watershed management here.

During the first six months of the Project, Ramiro Agosto, long-time member of the Caribbean National Forest staff, was assigned to assist Tobiaski and Swensen in overcoming language difficulties, maintaining good public relations and helping generally with the study. Since all the study plots are located on private lands owned by Spanish speaking cooperators, his assistance was a valuable asset. Ramiro is still with the project on a part-time basis. Pepe Lefebre, formerly with Utilization Research, is now the junior member.

The study is about one-half complete, the wet half. We are still looking forward to the dry season which had begun in January but was rudely interrupted by a week of heavy rains at the end of the month. On the north coast, near Dorado, seven inches of rain were recorded during the first two days and eight inches for the next five at the rate of about 1.5 inches per day. Several of the study sites were inundated for a short time. The intensity of the rain reached as high as 6 to 7 inches per hour for short periods

Jerry Horton spent a wet week on the Island (his second he claims) looking over the study sites and answering questions concerning the study. He also brought plans for drawing a trafficability map of the island.

Plans for the forthcoming Tropical Forestry Training Course for foreign students include a demonstration of soil sampling and soil strength testing techniques used on the project.